Research Priorities for Environmental Management in British Columbia

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EXECUTIVE SUMMARY

1) The purpose of this report is to assess the state of knowledge of environmental issues in British Columbia and to identify key environmental research priorities. The primary audience for this study is the environmental research community and funding agencies who can use the results of this project to help set research priorities.

2) The approach used in the study is an expert opinion survey based on a structured questionnaire and interview of leading environmental experts in British Columbia. The questionnaire includes questions dealing with the severity, causes, impacts, solutions and knowledge gaps for key environmental issues. The views summarized below represent those of the experts interviewed and do not represent the views of the authors of the study or the provincial government.

3) The experts surveyed were divided into two groups: comprehensive experts possessing broad knowledge across a large number of environmental issues, and specialist experts possessing in-depth knowledge of one or more specific environmental issues. In total, 83 experts, representing a diverse range of disciplinary and institutional backgrounds from government, academia, non-governmental organizations and the private sector, completed the questionnaire and follow-up interview. An advisory group of environmental experts was formed to assist in the design and completion of the study.

4) Respondents were asked to rank the severity of environmental issues in British Columbia in three different ways: unprompted open-ended questions, prompted numerical ratings of current severity, and a prompted numerical ratings of future severity in the next 10 to 15 years. The prompted numerical ratings were based on the nine predefined environmental issues listed below. Although all nine issues are serious and require assiduous attention, it is possible to rank them into the following three categories based on the questionnaire results. Within each category of seriousness, there is no differentiation made between the issues listed.

Very serious	Serious	Less serious
• Climate change/Global warming • Fish resource management • Biodiversity • Water resource management	• Air quality • Forest resource management	• Stratospheric ozone layer depletion • Soil management • Toxics

5) The major causes of environmental problems identified by respondents are underlying values such as materialism or lack of appreciation for the significance of ecological values, overconsumption of resources, population growth and inadequate policies and planning.

6) The key solutions to environmental problems identified by respondents are increased incentives to reward good environmental practices such as tax shifting, public environmental education, stronger implementation of environmental plans and enforcement of regulations, better monitoring of outcomes, stronger integration of environmental objectives into decision-making, and increased scientific research in key areas summarized below.

7) The majority of respondents (78 %) expect British Columbia's environment to deteriorate over the next 10 to 15 years. Respondents also on average expect each of the nine environmental issues to become more serious over the next 10 to 15 years. The principal explanation for this trend cited by respondents is that the impacts of continued strong population and economic growth will outweigh improvements in environmental policy.

8) Knowledge of causes and solutions to environmental problems is generally ranked as moderate to high by respondents. Action to solve these problems is ranked relatively low for all problems except ozone. This suggests there is a major "action gap" between what can be done and what is currently being done to manage environmental problems. The emphasis in environmental research should therefore be on how to achieve more effective policy implementation.

9) Respondents rate research communication within the environmental research community and communication between this community and the public as marginally adequate. Major constraints impeding communication and dissemination of research results are lack of time for interaction, institutional barriers impeding interchange between different agencies, intellectual barriers impeding interaction between different disciplines, lack of organized forums for communication, and lack of objective information sources. Respondents' suggestions for improving communications and improving synergies in the research community include increasing support for research activities and professional development within government, increasing the number of conferences and forums for the interchange of research findings, and improving public reporting of environmental research.

10) In response to an open-ended question on research priorities, respondents identified several priority areas. The top three are generic areas of research relevant to all environmental areas. They include design and operation of a comprehensive state-of-environment monitoring system, policy research on how to integrate better environmental objectives into the decision-making process, and policy research on how to better implement environmental policies. Other research priorities identified by respondents include impacts of climate change, threats to fisheries, and research on how to protect biodiversity. Research on forestry, water, air, and ecosystem issues were also mentioned; although less frequently.

11) Respondents were also asked to identify research priorities for each of the nine environmental problems. The results are summarized below.

Environmental Category	Research Priorities
Climate Change/Global warming	• policy design and implementation • impacts on regional ecosystems • alternative energy sources • adaptive strategies
Stratospheric ozone	• compliance monitoring • impacts on flora and fauna • ozone layer dynamics
Air quality	• human health impacts • policy design and implementation
Water resource management	• human health impacts of contaminants • policy implementation • monitoring water quality • watershed restoration
Biodiversity	• inventory and monitoring

	• habitat requirements of key species • impact of alternative resource harvesting
Forest resource management	• impact of alternative harvesting methods • integrating environmental objectives into forest planning • relation between competitiveness and conservation
Fish management	• impact of threats • inventory and stock assessment • alternate management regimes
Toxics	• impacts on human health and ecosystems • development of safe alternatives
Soil management	• monitoring and inventory of soils • impact of alternative forest harvesting and agriculture methods

11) One of the initiatives recommended by respondents is the need for developing and implementing a comprehensive state-of-environment monitoring system which is based on sustainability indicators, provides an early warning system, gives a comprehensive assessment of environmental trends, is user friendly and independent of special interests. A number of respondents recommended that monitoring be done by an independent agency structured under its own statute specifying annual reporting requirements.

12) Another initiative recommended by respondents to increase synergies in environmental research is a regular environmental conference organized by an independent entity such as a university focusing on British Columbia's environmental issues, bringing together relevant stakeholders to discuss research findings.

13) A third initiative recommended by respondents involves increasing research efforts to fill the key knowledge gaps identified above. Respondents emphasize that research needs to be interdisciplinary and supported by stable funding. The Centres for Excellence approach in which top researchers are integrated into a coordinated research effort appears to be the model that best meets this objective. Research institutes could be set up at British Columbian universities to manage and help coordinate research efforts in high priority areas identified by respondents such as environmental policy, climate change, fish, and biodiversity. According to respondents policy research should include research on environmental monitoring systems, implementation strategies such as tax shifting, and methods for integration of environmental objectives into decision-making.

ACKNOWLEDGEMENTS

We would like to thank a number of agencies and individuals for their assistance in completing this study. First we would like to thank the provincial government for providing financial support for the completion of this project. Second we wish to thank the advisory group for their help in developing the methodology, the questionnaire and reviewing the research results. Finally we wish to thank the respondents for their valuable time and insights that went into completing the questionnaire and making the project possible. The names of the agencies and individuals involved are summarized in Appendix 1.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 1 Purpose of Study

1.1 Introduction

One of the key priorities of British Columbians is the protection and maintenance of a healthy environment. Human health is reliant on clean air and clean water. Economic prosperity depends on the protection and sound management of natural resources such as fish, forests and natural beauty -- the basis of British Columbia's economic activities and quality of life.

The maintenance of a healthy environment is contingent on a sound understanding of environmental processes. The purpose of this study is to assess the state of knowledge of environmental issues in British Columbia and to identify key research priorities. The primary audience for this study is the environmental research community and funding agencies who can use the results of this project to set the research priorities that need to be pursued to provide the knowledge necessary for sound environmental management. Specifically the objectives of this study are:

1) to identify current and future environmental issues in British Columbia;

2) to assess critical gaps in knowledge about these environmental issues;

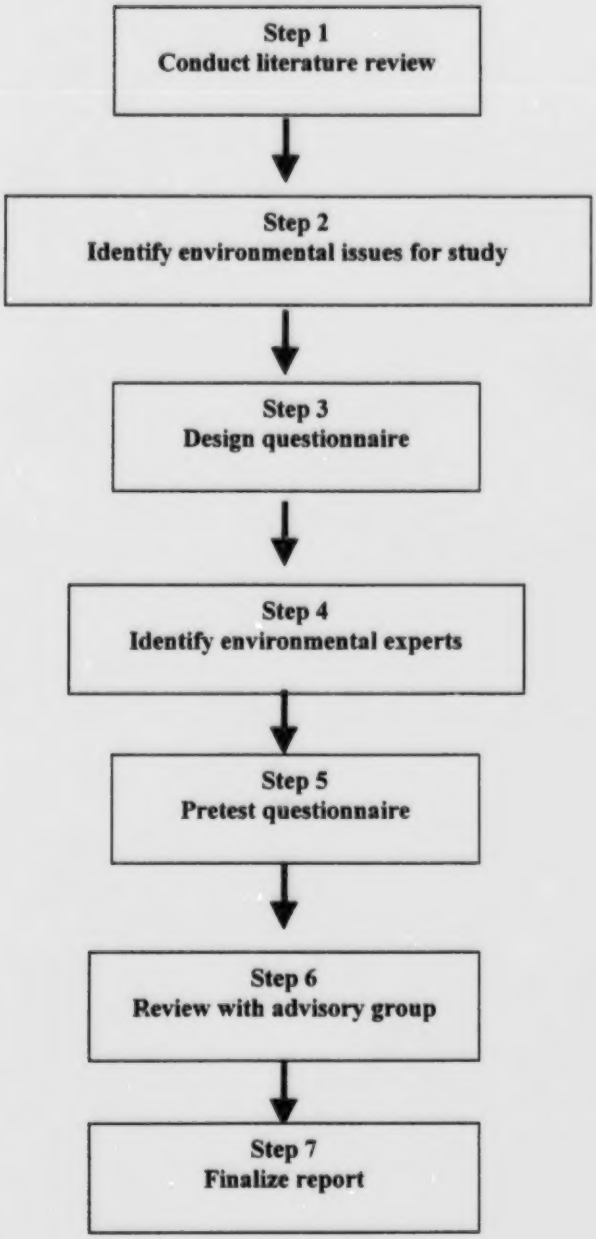
3) to identify strategic research priorities necessary to fill critical knowledge gaps;

4) to assess opportunities for improving linkages in the environmental research community, improving synergies in research, and to expedite the diffusion of research findings.

1.2 Methodology

The approach for this study is an expert opinion survey. The steps in the study are summarized in Figure 1. An advisory group of environmental experts was formed to assist in the design of the study and provide advice at various stages in the study process. The composition of the advisory group is contained in Appendix 1.

Figure 1 Steps of study process



The first step in the study was to complete a review of relevant literature regarding environmental issues, the state of knowledge on these issues, and to identify key environmental researchers.

The second step was to identify the environmental issues for the study. Based on the literature review and discussions with the advisory group, the following nine categories were chosen. These problem descriptions are provided to give a general idea of the problem area being considered; they are not intended to be an all-inclusive, definitive description of the problem. It is important to note that while it is useful to break environmental issues into separate categories and identify specific aspects of individual issues, environmental issues should also be considered from a holistic perspective because they are inherently interdependent. Accordingly, the questionnaire is designed to review these issues from a holistic perspective as well as from an issue specific point of view.

Table 1 Environmental issues in study

Issue	Description
1) Climate change and global warming	Elevated levels of greenhouse gases causing changes to the earth's climate
2) Stratospheric ozone layer depletion	Ozone-depleting substances thinning the ozone layer in the atmosphere
3) Air quality	Concentrations of contaminants in the air throughout British Columbia that result in poor air quality
4) Water resource management	Concentrations of contaminants in and altered physical characteristics of surface and groundwater that result in poor water quality; water exports; flooding; groundwater extraction; community water supply; watershed management
5) Biodiversity and endangered species	Decreasing genetic diversity (variation among individuals of the same species), species diversity and ecosystem diversity
6) Fish resource management	Declining fish stocks, habitat loss, weakened supporting aquatic systems, overfishing
7) Forest resource management	Rate and distribution of timber harvest, harvesting techniques, reforestation and silviculture systems, protected areas
8) Toxic contaminants	Increasing concentration of metal, organochlorines, endocrine disrupters etc.
9) Soil management	Soil erosion, soil salinization, soil nutrient depletion, soil structure destruction

The third step was to design a questionnaire for the interviews. The questionnaire, provided in Appendix 2, is divided into four parts. Parts I and II deal with environmental issues from a holistic, integrated perspective, while Parts III and IV review them from the more detailed perspective of the nine environmental categories.

Part I

Set of open-ended questions asking the respondent to identify:

- the most serious environmental problems in British Columbia
- the principal causes of these problems
- steps to mitigate these problems
- key environmental research priorities
- overall trends in environmental quality.

Part II

Set of open-ended questions asking the respondent:

- to assess the adequacy of communications between researchers and the public
- to identify means of improving synergies in research
- to identify means of improving communication of research results.

Part III

Structured assessment of the current and future seriousness of the nine environmental issues.

Part IV

For each of the nine environmental issues, structured questions on the state of:

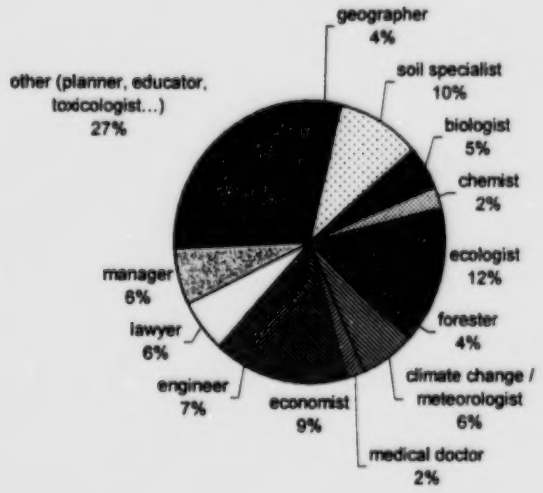
- knowledge of impacts
- data collection
- causes
- solutions
- knowledge gaps
- recommended research priorities.

The fourth step was to identify the environmental experts to be interviewed. The list of experts is contained in Appendix 1. The experts were divided into two groups – **comprehensive experts**, possessing a broad knowledge across large number of environmental areas; and **specialist experts**, possessing in-depth knowledge of a limited number of environmental issues. A panel of between five and nine specialist experts was identified for each of the nine environmental issues listed above.

Both comprehensive and specialist experts were asked to complete the open-ended questions in Parts I and II, as well as the rating questions in Part III. In Part IV, comprehensive experts were asked to answer the questions for as many of the nine environmental issues as they felt they had appropriate expertise and knowledge. Most comprehensive experts answered questions for an average of four to six issues. Specialist experts were asked to answer questions in Part IV for only the specific environmental issue panel(s) to which they were assigned. The use of both comprehensive and specialist experts ensures that the expert knowledge included both in-depth expertise relevant to the particular issue being assessed as well as broader expert knowledge that allowed for comparisons between issues.

In choosing the experts it was important to ensure adequate representation from all relevant disciplines and institutions. Based on the literature review and discussion with the advisory group about 80 experts were initially asked to participate in the study. Some were unable to participate and were replaced with comparable experts. In total, 111 experts were asked to participate in the study. Of these, 83 completed the questionnaire, resulting in a participation rate of 75 %. Figure 2 illustrates that the participating experts represent a diverse disciplinary background ensuring a broad range of expert views. In most cases, the expert panels included representation from government, academia, non-governmental organizations (NGOs) and the private sector.

Figure 2 Disciplines of respondents



The fifth step was to pretest the questionnaire with the advisory group and make any necessary revisions. After the pretest, questionnaires were sent out to potential respondents. Returned responses were reviewed by the researchers. In almost all cases, follow-up interviews were conducted in person or on the telephone to allow for elaboration or clarification of responses.

The final steps were to review and assess the results with the advisory group for comment and complete this report summarizing the study and its findings.

1.3 Report Structure

The report structure generally follows the structure of the questionnaire. Chapter 2 of the report provides a summary of the Part I questionnaire results. These are based on open-ended questions asking respondents to identify the most serious environmental problems in British Columbia, the causes of these problems, proposed solutions and research priorities. Chapter 3 of the report summarizes Part III of the questionnaire dealing with the current and future severity of the nine environmental issues. This chapter also includes a comparison of key attributes of the nine issues.

The fourth chapter of the report is a detailed review of the questionnaire results and relevant secondary literature for each of the nine environmental issues based on Part IV of the questionnaire. This is followed by Chapter 5, a review of the questionnaire results on communication and interaction among researchers and the public. The final chapter provides overall conclusions.

The summaries of questionnaire comments contained in this report are abbreviated reviews of over 2,000 pages of responses. As such, judgements have been made as to what are the key statements in the responses and how to categorize and organize them succinctly. Those wanting a more extensive review of the contents on the questionnaires can consult Volume II. For a statistical summary of questionnaire responses, please see Appendix 3.

Chapter 2 Overview of Environmental Issues

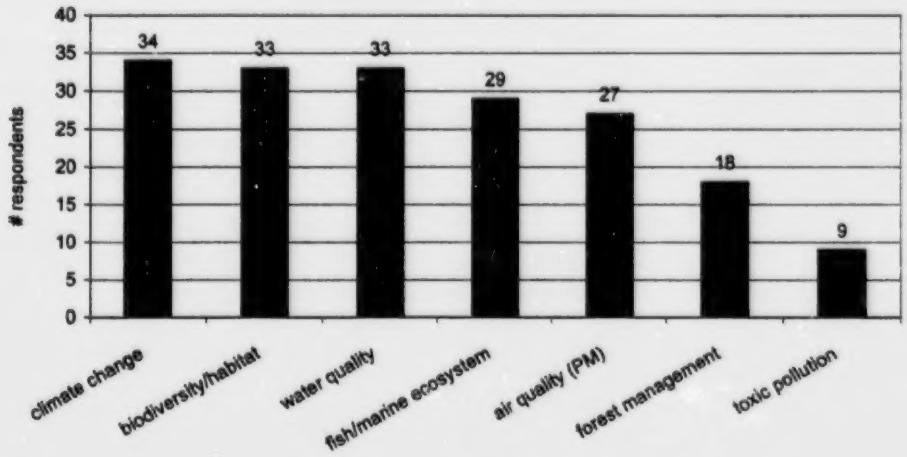
2.1 Identifying Environmental Problems

In Part I of the questionnaire, respondents were asked to identify the most serious environmental problems in British Columbia based on both current and future implications. The questions were open-ended and respondents could identify as many problems as they wished.

The results summarized in Figure 3 show that six environmental issues dominate: climate change, loss of habitat and biodiversity, water quality, fish and marine ecosystems, air quality (primarily particulate matter in air which causes human health problems), and forest management. The next tier of problems such as toxic pollution are well behind these six dominant issues.

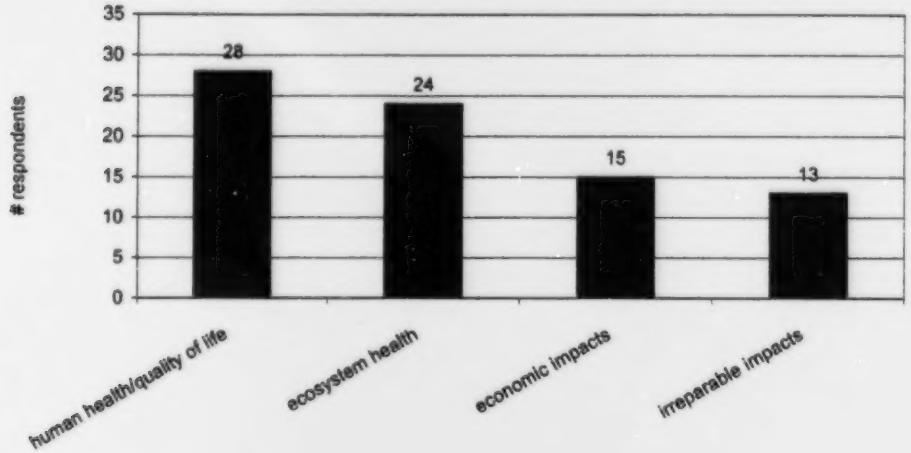
Respondents also identified a number of other issues in response to this question such as population growth, inadequate policy, urbanization, and excessive dependence on the automobile. These are more accurately viewed as causes of environmental problems and are included in the discussion in section 2.2. However, it is important to note that many respondents considered the environmental problems identified in Figure 3 to be interdependent and symptoms of more deep-rooted problems such as growth, which are the underlying drivers of environmental decline.

Figure 3 Part I – Most serious environmental problems
Part I, Question 1 (open-ended)
Considering both current and future implications,
what are the most serious environmental problems in BC?



Respondents were asked why they think these problems are so serious. They used four key criteria in their ranking: direct impact on human health and quality of life, impact on ecosystem health, impact on the economy, and whether the impact was irreparable or not. These responses are summarized in Figure 4.

Figure 4 Part I – Reasons for seriousness of problems
Part I, Question 2 (open-ended)
Why do you think these problems are so serious?



2.2 Causes of Environmental Problems

Respondents were asked to identify the underlying causes of environmental problems in British Columbia. Again, the responses were open-ended and respondents could identify as many causes as they wished.

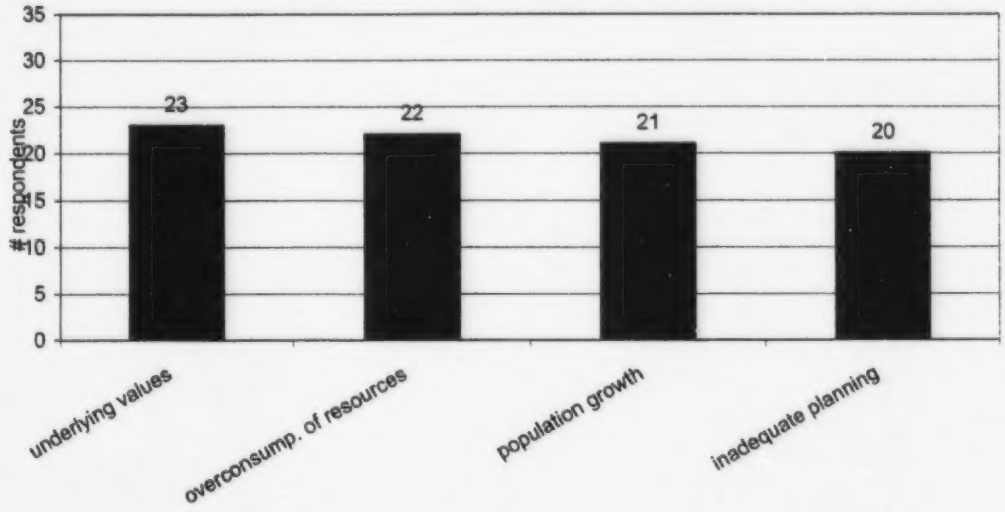
The results summarized in Figure 5 show that the top four causes of environmental problems have approximately the same number of mentions. The cause labeled *underlying values* includes materialism, poor public understanding of the significance of environmental problems and the consequences of their lifestyle choices. Many experts also stated that human behavior is based on the wrong paradigm, assuming growth is good and that the environment can be "managed" to meet excessive human demands.

The next two causes, labeled *overconsumption of resources* and *population growth*, are linked - many respondents emphasized that per capita consumption of resources, not just population, is the key factor. The ecological footprint of one person in a wealthy country such as Canada far exceeds that of a poor person in an underdeveloped economy. In British Columbia overharvesting of fish and timber resources were the most frequently mentioned examples by respondents of the problem of overconsumption.

Another cause identified by respondents is *inadequate planning*. This incorporates a number of concerns including lack of integrated planning (this is defined largely as failure to adequately include multiple objectives such as conservation in planning), weak implementation and enforcement of

existing plans and policies, inadequate legislative framework for planning, short term and narrow objectives, and inadequate financial and personnel resources for planning and management. Respondents also referenced the need to strengthen institutional capacity for integrated planning. Land-use planning was the most frequently mentioned area where improvements could be made.

Figure 5 Part I -- Causes of environmental problems
Part I, Question 3 (open-ended)
What would you identify as the most significant
underlying causes of environmental problems in BC?



2.3 Solving Environmental Problems

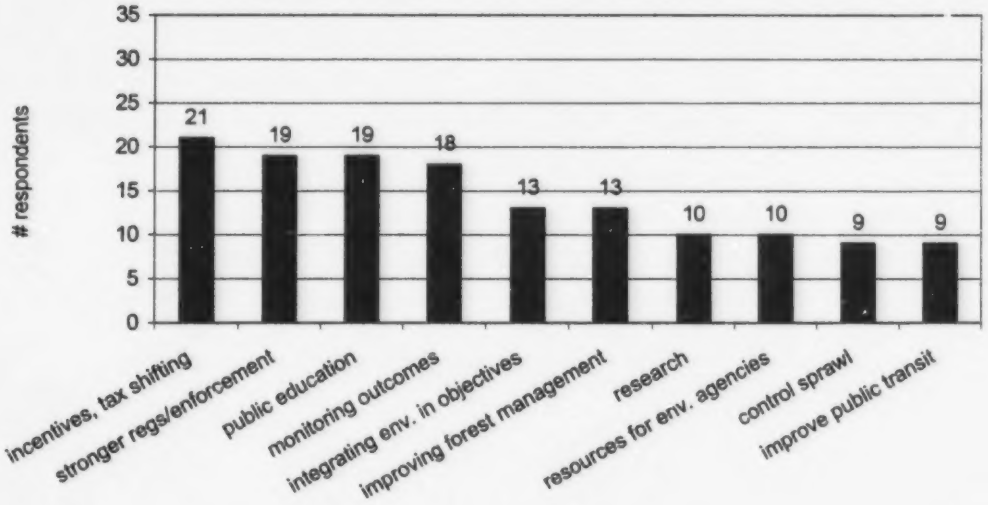
After identifying the causes of environmental problems, respondents were asked in an open-ended question to identify the most significant steps the British Columbia government could take to address environmental problems.

The responses summarized in Figure 6 represent a comprehensive action plan integrating mutually reinforcing initiatives. Considerable reference is made by respondents to expanding incentives to encourage environmentally friendly behavior such as tax shifting (which involves increasing taxes on environmentally destructive behavior such as driving single occupancy cars), and reducing taxes on environmentally friendly behavior such as purchasing low-polluting cars or using public transit. This is closely followed by calls for setting and enforcing tougher environmental regulations.

Considerable mention is also made by respondents of the need for improving environmental education so that the public better understands both the seriousness of environmental problems and the consequences of consumer choices. A related key recommendation of respondents is the need for comprehensive environmental reporting and monitoring. Clear, desired outcomes need to be set for each environmental issue and ongoing auditing and public reporting done to assess results and the state of environmental health. Many respondents conclude that failure to adequately report environmental trends is at the root of many of the current problems.

Additional suggestions made are to ensure greater inclusion of environmental objectives into the planning process, improve forest management, undertake more research, increase resources for environmental agencies, control sprawl, and improve public transit.

Figure 6 Part I -- Steps for BC Government to address environmental problems
Part I, Questions 4 and 5 (open-ended)
What is/are the most significant step(s) the BC government could take to address environmental problems?



2.4 Research Priorities

Respondents were asked what the environmental research priorities should be in British Columbia. Again the question was open-ended and allowed for multiple responses. Figure 7 summarizes the results.

The top three research priorities involve generic research relevant to all environmental issues. The first priority, *monitoring*, involves research on how to design and operate a comprehensive environmental monitoring and reporting system which is based on key sustainability indicators, provides an early warning system, assesses progress towards stated environmental objectives, is user friendly and easy to understand. For illustration, some experts cited the utility of emulating the environmental equivalent of economic indicators such as unemployment and economic growth data which are reported on a regular basis, are easy to understand, and provide a timely assessment of the state of the economy.

The second priority cited by experts is research on how to improve the policymaking process and institutional structures to achieve better integration of environmental objectives into decision-making. Specific research proposals include development of full-cost accounting, risk management techniques based on the precautionary principle, and evaluation of practices in other jurisdictions to identify "best practices" for adoption in British Columbia. This emphasis on research on the policy process

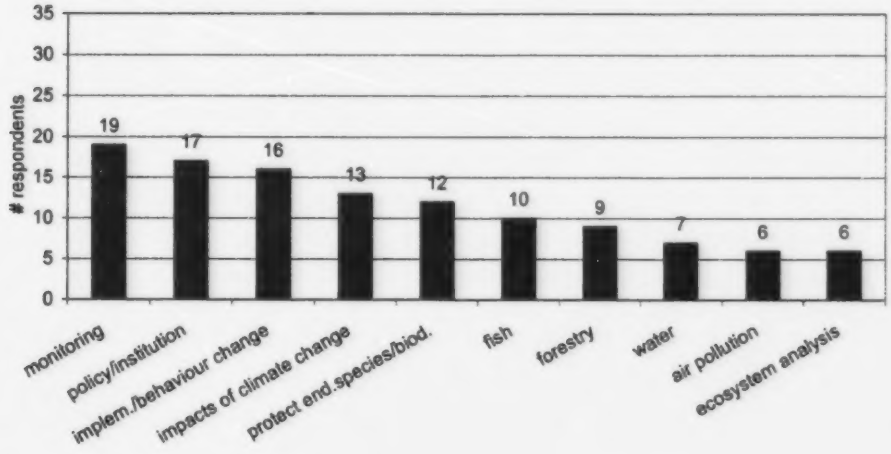
logically follows from the conclusion that better planning and policy making is one of the keys to solving environmental problems.

The third and related research priority is how to more effectively implement environmental policy to achieve the necessary changes in behavior. A frequent comment was that we understand the problem and what needs to be done to solve it but we do not understand how to implement the solution in a publicly acceptable way.

The remaining research priorities cited by the experts relate to research on specific environmental issues. These include:

- impacts of climate change
- measures to protect endangered species and biodiversity
- relative contribution of the various threats to fish (e.g., overfishing, habitat loss, climate change)
- forestry practices
- water pollution
- air pollution
- scientific analysis of ecosystem dynamics.

Figure 7 Part I – Environmental research priorities for BC
Part I, Questions 6 and 7 (open-ended)
What should be the environmental priorities for BC?



2.5 Environmental Trends

The final section of Part I of the questionnaire dealt with environmental trends. Respondents were asked on a scale from 1 to 10 to rank the change in environmental quality in British Columbia over the next 10 to 15 years with 1 representing significant deterioration, 5 representing no change, and 10 representing significant improvement. The results summarized in Figures 8 and 9 show that a large majority of respondents (78 %) expect overall environmental quality to deteriorate over the next 10 to

15 years, while only 13 % expect it to improve. The average ranking was 3.45, which suggests a modest as opposed to precipitous decline.

Figure 8 Part I – Future outlook of BC's environmental quality
Part I, Question 8
How do you think BC's environmental quality is likely
to change over the next 10 to 15 years?

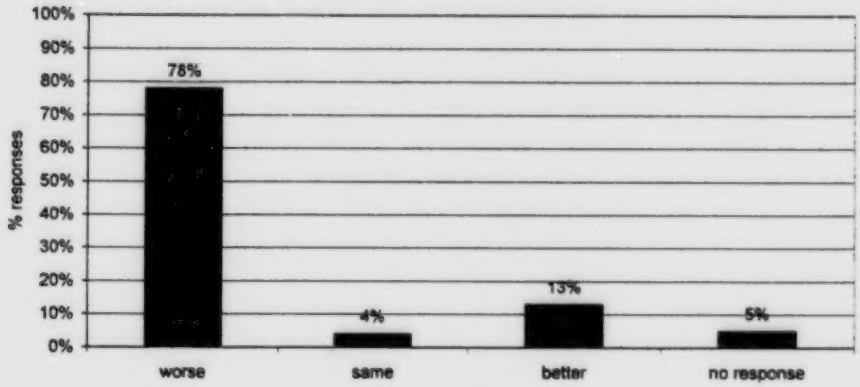
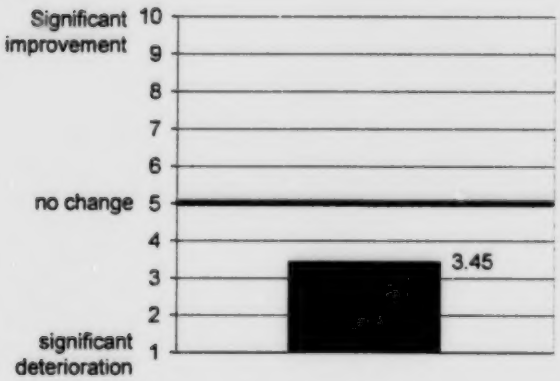
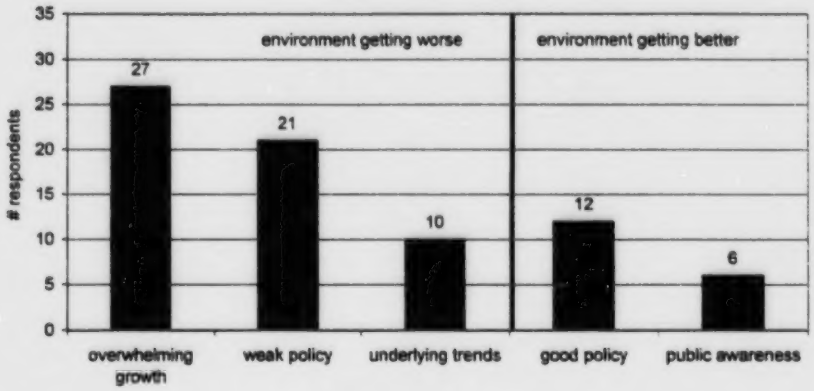


Figure 9 Part I – Future outlook of BC's environmental quality (average)
Part I, Question 8
How do you think BC's environmental quality is likely
to change over the next 10 to 15 years?



Respondents were also asked to provide the rationale for their rating. The results are summarized in Figure 10. In viewing these results it should be noted that many respondents cited areas of the environment that they expected would improve over the next 10 years but concluded that these would be outweighed by the areas of decline, thus resulting in an overall deterioration.

Figure 10 Part I – Reason for future outlook of BC's environmental quality
Part I, Question 9
Please provide the rationale for your answer to Question 8



The most common explanation for the anticipated decline in environmental quality is that the rapid rate of growth in British Columbia will outweigh improvements in environmental management. The significant improvements in policy and programs that are occurring in British Columbia will not be able to keep up with growth.

The second most frequent response is that policy efforts are simply too weak and are the principal reason for the anticipated decline. A third response cited underlying trends such as climate change being so strong that no policy effort is capable of reversing them.

Finally, the small minority of respondents that anticipate an improvement in environmental quality conclude that this will occur because of ongoing improvements in environmental policy and increased public awareness of environmental issues.

Chapter 3 Comparative Overview of Environmental Issues

3.1 Introduction

Parts III and IV of the questionnaire asked a series of detailed questions about the nine specific environmental problems listed in section 1.2 of this report. The questions dealt with a number of issues including the current and future seriousness of the problem, impacts, adequacy of monitoring data, causes, and solutions. The purpose of this chapter is to provide a brief comparative overview of the findings in Parts III and IV. Chapter 4 of the report provides a more detailed summary for each of the nine environmental problems.

3.2 Comparative Results

Part III of the questionnaire asked respondents to rank the seriousness of the nine environmental problems in British Columbia both currently and 10 to 15 years from now; the rankings were based on a scale from 1 to 10, with 1 being not at all serious and 10 being very serious. The results are summarized in Figures 11 and 12, showing the average ratings for each problem. Fisheries issues dominate as the most serious problem both now and 10 to 15 years from now, while ozone, soils and toxics are the least serious. Interestingly, all nine problems are expected to get worse, with the greatest deterioration occurring in climate change, biodiversity, and water, as illustrated in Figure 13. Climate change and biodiversity move up to the second and third most serious problems in the future from their current rankings of seventh and fourth most serious problems, respectively. The rest of the problems are anticipated to show increases in ratings of about 1 or less.

Figure 11 Part III – Seriousness of specific issues currently
Part III, Question 1
On a scale from 1-10, how serious do you think each of these problems is for British Columbia currently? *Averages shown*
Where 1 (not at all serious), 10 (extremely serious)

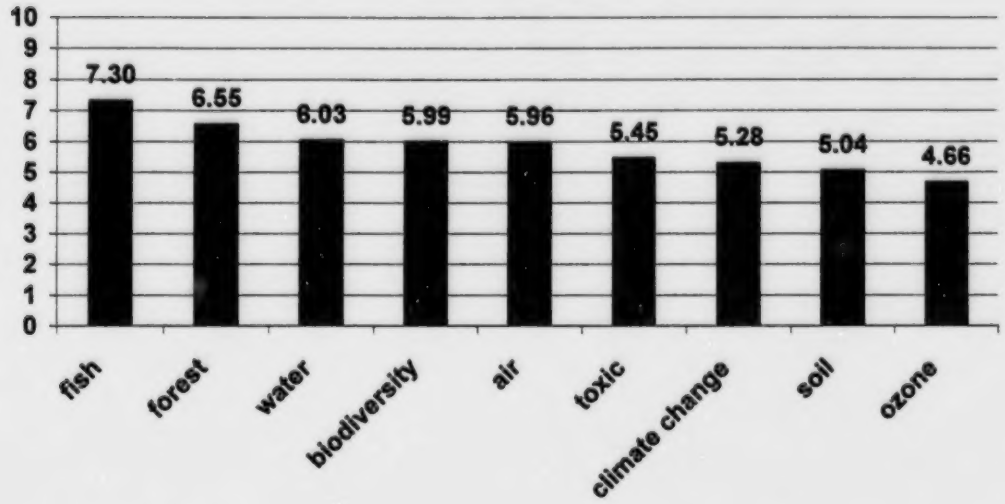


Figure 12 Part III – Seriousness of specific issues both currently and in the future
Part III, Question 2
On a scale from 1-10, how serious do you think each of these problems will be for British Columbia in 10 to 15 years? Currently? *Averages shown*
Where 1 (not at all serious), 10 (extremely serious)

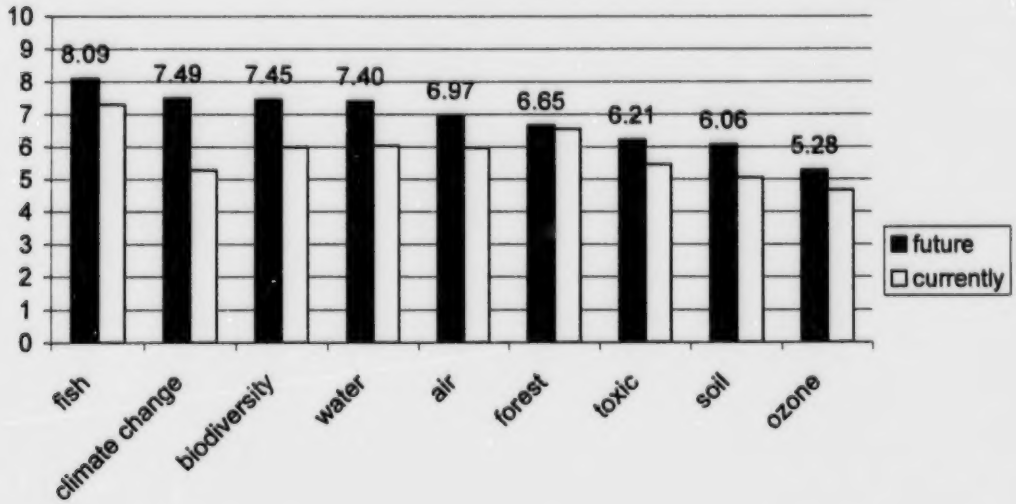
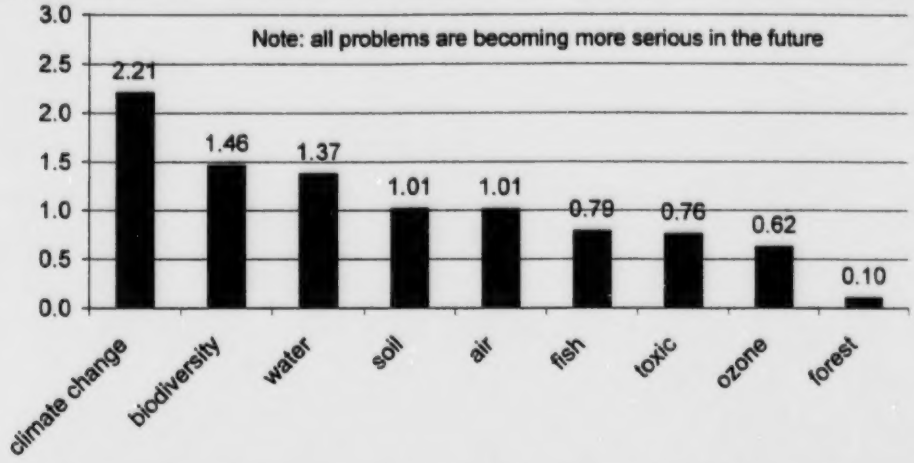


Figure 13 Part III -- Difference between seriousness of issues currently and in future



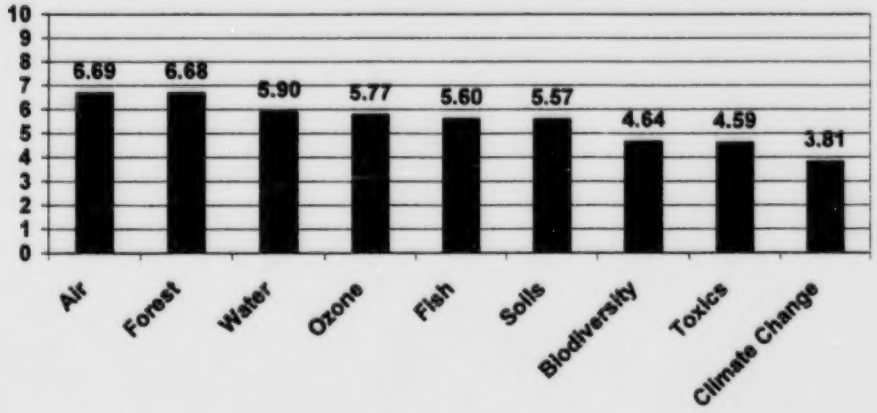
In Part IV, a number of additional ranking questions were asked for each of the nine problems. The first one asked respondents to assess how well the impacts of the problem are understood on a scale from 1 to 10, with 1 being no understanding and 10 being a thorough understanding. The results summarized in Figure 14 show that the level of understanding of the impacts of most problems is moderate to good except for biodiversity, toxics, and climate change.

Figure 14 Part IV -- Understanding of impacts

Part IV, Question A2

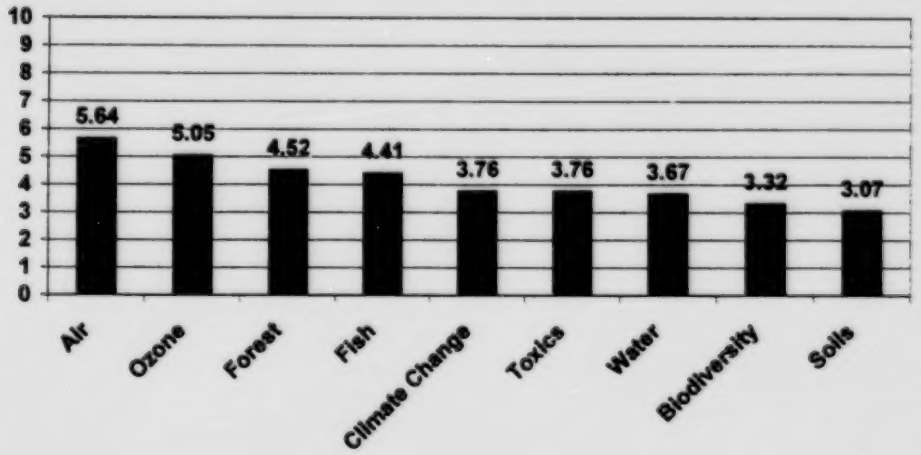
How well do we understand the impacts of the problem in BC? *Averages shown*

Where 1 (we have no understanding), and 10 (we have a thorough understanding)



A second ranking question asked respondents to assess the adequacy of basic monitoring data in terms of informing the management of the problem. The results summarized in Figure 15 show that monitoring data is moderate to poor quality for all nine problems. This suggests the basic information on the state of British Columbia's environment is inadequate. Specific data gaps are discussed in Chapter 4 under the respective environmental issues.

Figure 15 Part IV - Adequacy of monitoring
Part IV, Question B1
How good is our basic monitoring data for this problem in BC
in terms of informing the management of the problem? *Averages shown*
Where 1 (very poor quality and quantity of monitoring data),
10 (excellent quality and quantity of monitoring data)

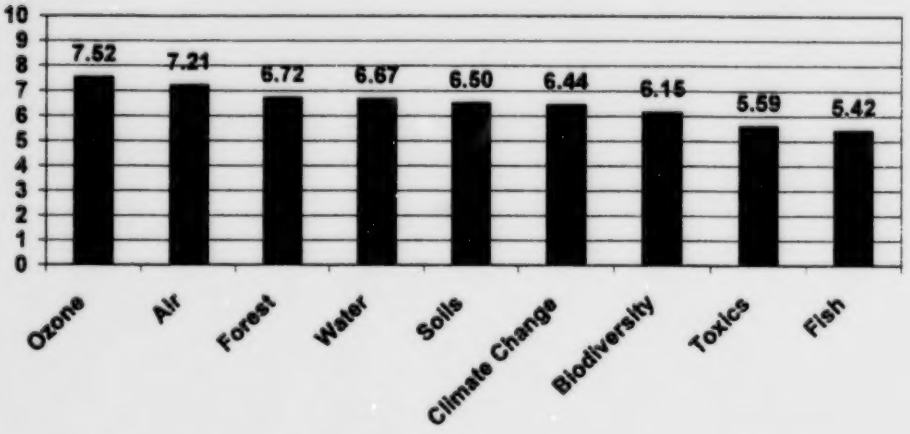


The next ranking question asked how well the causes of the problem are understood for the purposes of managing the problem. As Figure 16 illustrates, the understanding of causes was rated moderate to high for all nine issues, with air and ozone receiving especially high ratings.

Figure 16 Part IV - Understanding of causes

Part IV, Question C2

In terms of being able to manage the problem,
how well do we understand the causes of the problem? *Averages shown*
Where 1 (we have no understanding), 10 (we have a thorough understanding)



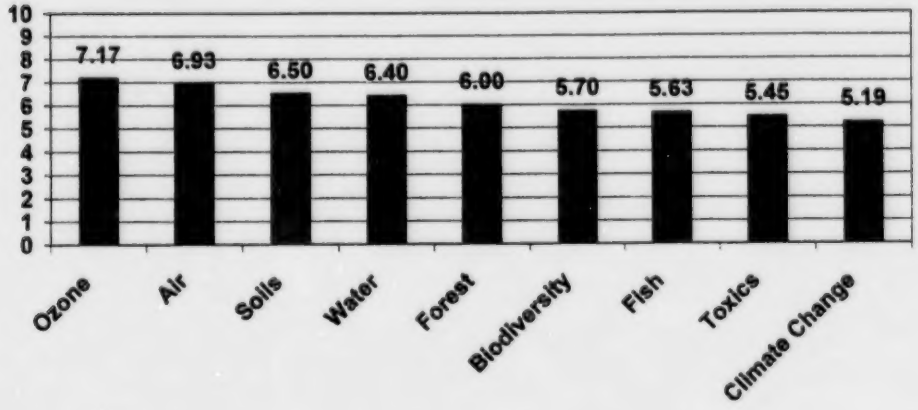
Respondents were then asked to rank current understanding of how to solve the problem. Again as summarized in Figure 17, the level of understanding of how to solve the problems is moderate to high for all nine problems.

Figure 17 Part IV -- Level of understanding of how to solve the problem

Part IV, Question D2

How well do we understand how to solve the problem? *Averages shown*

Where 1 (we have no understanding), 10 (we have a thorough understanding)



The last ranking question asked respondents to assess on the 1 to 10 scale how well the problem is being managed. Here the rankings for all nine issues except ozone are poor (as summarized in Figure 18). The results of Figures 17 and 18 were then compared to show the gap between the understanding of solutions and the current actions to manage the problem. These results, which are shown in Figure 19 , are the difference between the understanding rating in Figure 17 and the addressing the problem rating in Figure 18, they show that there is a substantial action gap for all issues except toxics and ozone, where action is relatively consistent with knowledge. This suggests that while knowledge gaps exist in all aspects of the nine environmental problems, the key gap or constraint in managing environmental problems is the implementation of solutions.

Figure 18 Part IV – How well we are actually addressing the problem

Part IV, Question D3

How adequately are we currently addressing the problem? *Averages shown*

Where 1 (we are not addressing the problem adequately at all),

10 (we are addressing the problem very adequately)

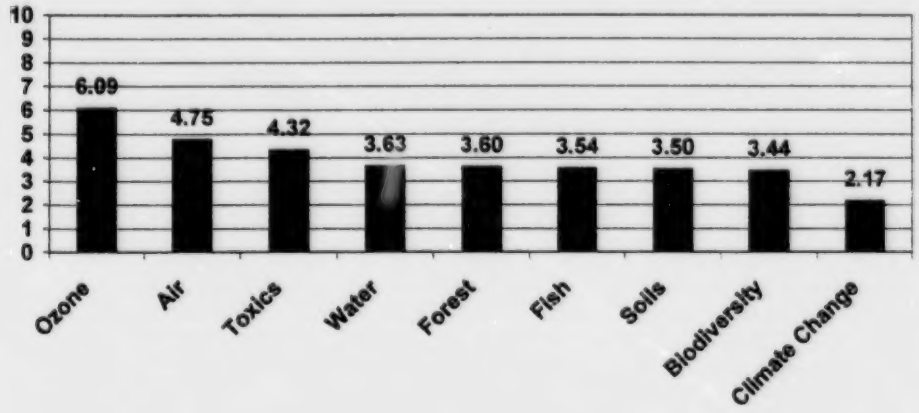
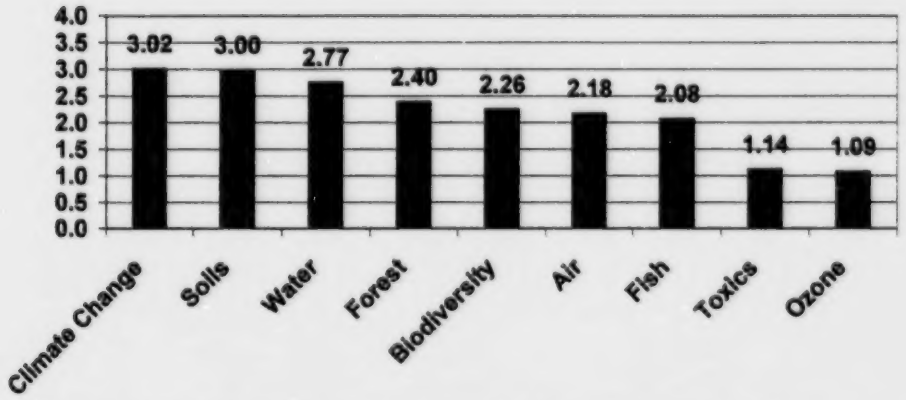


Figure 19 Part IV – Action gap

Difference between averages of responses to

D2 (how well we understand how to solve the problem) and

D3 (how well we are currently addressing the problem)



Note: for all problems, we understand the problem better than we are addressing it

Chapter 4 Detailed Review of Specific Environmental Issues

4.1 Introduction

The purpose of this chapter is to provide a more in-depth review of the nine environmental problems based on Part IV of the questionnaire. Each of the following sections begins with an introductory overview of the issue in question, based on secondary sources. This is then followed by a summary of the questionnaire results. A more detailed summary of the questionnaire results for each environmental issue is contained in Volume II. For a statistical summary of questionnaire responses, please see Appendix 3.

4.2 Global Warming

4.2.1 Overview

The environmental effect referred to as climate change is based on the human enhancement of a natural phenomenon, the so-called greenhouse effect. For thousands of years, the sun's solar energy has passed through the earth's atmosphere, been absorbed by the earth's surface, and eventually radiated back to the atmosphere. As part of this natural process, some of the energy radiated from the earth's surface is trapped by gases in the atmosphere, effectively keeping the planet warm. This "greenhouse" effect is an essential part of maintaining the earth's climate and ecosystems, without which the average temperature on the earth's surface would be approximately -18°C instead of the normal 15°C (province of BC 1995). However, human-induced changes to the atmospheric concentrations of greenhouse gases over the last 150 years seem to be enhancing the greenhouse effect, resulting in changes to the earth's climate. This global warming effect is also referred to as climate change, reflecting the observed and expected changes in climate as a result of warming trends.

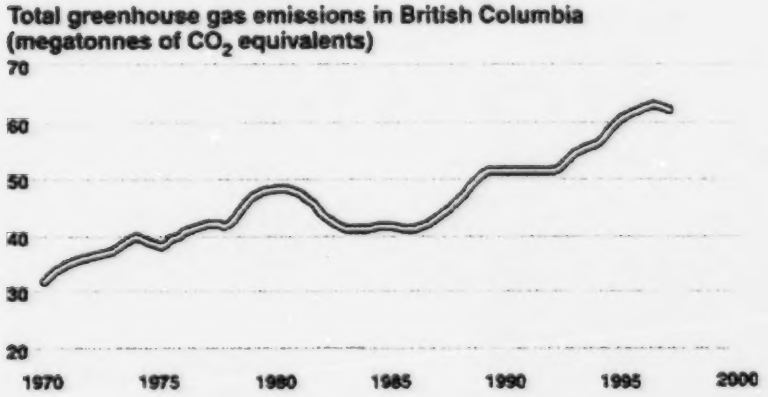
Climate change will have direct effects on British Columbia, some of which are already becoming evident. Over the last century, average temperatures in BC have risen 0.5° to 1.7°C (Ministry of Environment, Lands and Parks 2000). It is estimated that over the next 100 years, the average temperature in BC will increase 7°C in the winter and 4°C in the summer, with an uncertainty of 3°C (Province of British Columbia 1995). As a result, there will likely be more rain on the West Coast, especially in winter months. In contrast, the Interior will likely get less rain, resulting in more frequent drought and forest fires, as well as increased pressure on local water resources. The anticipated rise in global sea levels could lead to major coastal flooding and erosion, destroying estuaries, dikes, private property, and aquaculture. Global warming could have a great impact on the forestry and fishery resource sectors as well. As a result of higher water temperatures, lower water salinity and changed ocean and stream currents, salmon stocks could change migratory patterns and be severely impacted. Forests could shift to higher elevations and northward, becoming more susceptible to pests, disease and fire (Environment Canada 1997).

Although the explanation for observed climate changes is still debated, the balance of evidence suggests that the primary cause is increased greenhouse gas concentrations in the atmosphere (Ministry of Environment, Lands and Parks 2000). Greenhouse gases (GHGs) include carbon dioxide, methane, nitrous oxide and perfluorocarbons (PFCs). Some GHGs, such as carbon dioxide, are naturally occurring; it is only because of their unnaturally high concentrations in the atmosphere that they enhance the normal greenhouse effect. Other GHGs, such as PFCs, are introduced to the environment only through human activity.

Canada has about 0.5% of the world's population and accounts for about 2% of the world's total GHG emissions. Internationally, Canada is the eighth highest carbon dioxide emitter, with the world's fourth highest per capita GHG emissions. Transportation is the largest source of GHG emissions in Canada, followed by industry, fossil fuel industries, and electricity generation. Nationally, GHG emissions have increased by 15% since 1990, and are expected to have increased by 26% by the year 2010 if current trends continue (Government of Canada 2000).

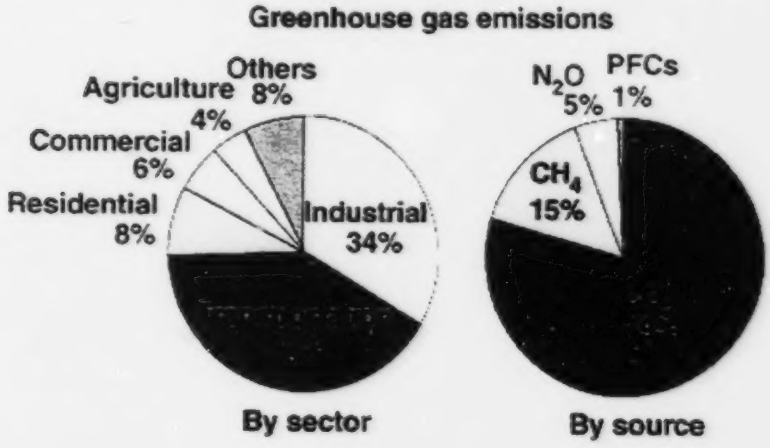
British Columbia contributed over 9% of Canada's total GHG emissions in 1997. As illustrated in Figure 20, BC's GHG emissions have increased 94% since 1970, and 21% since 1990. Although the per capita emissions have only increased 0.1% since 1990, BC's rapidly growing population is projected to increase total emissions by 38% over 1990 levels by the year 2010. As shown in Figure 21, transportation and industrial processes account for 75% of BC's GHG emissions, the majority of which are a result of burning fossil fuels (Ministry of Environment, Lands and Parks 2000).

Figure 20 Total greenhouse gas emissions in BC



(Ministry of Environment, Lands and Parks 2000)

Figure 21 BC Greenhouse gas emissions by sector



(Ministry of Environment, Lands and Parks 2000)

The concentration of greenhouse gases in the atmosphere can be reduced by burning less fossil fuels, using energy more efficiently, and enhancing the carbon sequestration process. This process captures carbon dioxide in carbon sinks, such as trees and soil, and slows its release to the atmosphere (Ministry of Environment, Lands and Parks 1998b).

Some government initiatives addressing the issue of climate change are listed in Appendix 4.

4.2.2 Impacts

The expert responses in the questionnaire confirm the impacts of global warming in the secondary literature summarized above. According to the experts the changes in the weather patterns caused by warming will lead to more intense rainfall in some areas of British Columbia and droughts in other areas. Overall, weather patterns are expected to be more erratic and more severe.

The change in weather will in turn have dramatic impacts on British Columbia's ecological system. Hydrological cycles will change, causing increased flooding in some areas and droughts in others. The change in flooding risks is particularly serious because the current flood control plans are based on past weather patterns which will be increasingly irrelevant in predicting future trends.

The change in hydrological cycles combined with the change in temperatures will have a significant impact on flora and fauna. Forests will suffer from changing growth rates, increased fires and increased losses due to pest infestations. Sensitive species will be under increasing stress as they try to adapt to changes in the biogeoclimatic dynamics. Fish, especially salmon, are especially vulnerable to the changes in water temperature which may result in the extinction of a number of runs and the migration of others north to cooler areas.

These changes in the ecological systems will have important economic and social impacts. Economic activities such as forestry, agriculture and fishing will experience major challenges due to the threats to the resource base on which they depend. Increased flooding, meanwhile, could cause billions of

dollars in damage to major urban areas including the Lower Mainland where flood plans are based on increasingly obsolete data.

Although the experts are agreed on the general impacts of global warming, they also emphasized in their responses that the knowledge of specific impacts is poor. Overall, they rated understanding of impacts on the 1 to 10 scale at only 3.8, the lowest rating for any of the nine environmental issues. In elaborating on this, some experts stated that while the understanding of macro climate change patterns was increasingly good, the understanding of climate change patterns at the regional level for geographic units such as British Columbia is poor. The understanding of the impact of these climatic changes on ecological systems at the regional level is very poor.

4.2.3 Monitoring

Experts rate the adequacy of monitoring data for climate change as poor. Their primary concern is that there is no overall strategy or framework for monitoring. Unresolved issues include specifying what needs to be monitored, how and who should collect the data and how the data should be managed and analyzed to ensure that it is useful for the management of this issue.

Respondents generally agreed that while the macro climate change data is reasonably good, the regional climate change data is poor and the monitoring of impacts on the ecological system at the regional level is very poor. Insufficient climate monitoring stations in British Columbia, insufficient monitoring of hydrological cycles and insufficient monitoring of ecological impacts are all cited by respondents as serious gaps.

4.2.4 Causes

Respondents rate understanding of the causes of climate change as relatively high. The source of greenhouse gases is well documented. Although there is still some uncertainty over the relative contribution of various factors such as long term climatic trends versus GHG on climate change, there is a virtual consensus that GHG emissions are a key cause of changing weather patterns.

In explaining causes, respondents went beyond the normal listing of sources of GHG to include factors such as failure to implement an aggressive emission reduction plan and the unwillingness of the public to change consumption patterns.

4.2.5 Solutions

Respondents rate understanding of solutions to climate change as moderate. Most respondents conclude that it is feasible to lower emissions of GHG. Examples cited included increased energy efficiency in new and existing buildings and lower emission vehicles. The lower per capita emissions in other developed economies as well as studies on the potential impacts in Canada of adopting current technologies were cited as evidence of the feasibility of achieving emission reductions.

Although respondents are generally optimistic that solutions exist, they are less sanguine about our understanding of how to implement them effectively. Tax shifting, for example, is a good idea but convincing the public to pay more for energy, even if they are getting a comparable reduction in other taxes, is a challenging endeavor. Respondents also point out that even if these solutions are adopted in British Columbia and Canada, this would have little impact on climate change because Canada

contributes only 2% of the world's GHG. Therefore an effective solution requires a major international effort which British Columbia could contribute to by showing leadership.

4.2.6 Barriers to a solution

While respondents rate understanding of solutions to climate change as moderate, they rate current efforts to address the problem the lowest of any of the nine issues. The two key barriers cited are lack of political leadership and lack of the public's understanding of the seriousness of the issue and their consequent unwillingness to change. Respondents also cite opposition by various stakeholders in the resource industry and the challenges of making the necessary changes domestically in a globally competitive economy.

4.2.7 Knowledge gaps and research priorities

The key knowledge gaps cited by respondents are understanding regional climate changes and their impact on ecological systems, understanding how to effect changes in human behavior, and understanding the cost-effectiveness and implementation strategies for alternative emission reduction measures.

The most frequently cited research priority is policy research on how to design, evaluate and implement emission reduction measures. This is followed closely by research on impacts of climate change on the British Columbia ecosystems, alternative energy sources, public education and adaptive strategies. The latter research area of adaptive strategies is strongly emphasized by several respondents who argue that climate change is inevitable, regardless of the success of efforts to reduce GHG emissions. Therefore research on how to adapt and manage these changes is just as important as research on how to reduce emissions. An example cited by respondents is the need to update flood management strategies to deal with the increased risk of severe flooding.

4.3 Stratospheric Ozone Layer Depletion

4.3.1 Overview

Ozone (O_3) is a naturally occurring substance composed of three bonded oxygen atoms. Although ozone can be found throughout the atmosphere, 90 % is concentrated in the stratosphere about 15 to 35 kilometres above the earth's surface in an area commonly referred to as the ozone layer. Even in this concentrated area, ozone only accounts for 1 in 100,000 molecules.

This ozone layer prevents much of the sun's harmful ultraviolet A, B (UV-A and B) and all ultraviolet C (UV-C) rays from reaching the earth's surface. However, a depletion of this ozone layer -- that is, a reduction in the concentration of ozone in the stratosphere -- results in a greater intensity of UV-B rays reaching the earth's surface. Although most organisms have evolved with some resistance to UV-B rays, an increase in UV-B would negatively affect humans, animals, plants, and non-living materials. For human beings, increased UV-B rays result in more incidences of skin cancer, sunburns, cataracts, blindness, eye diseases and complications due to immunosuppression (Ministry of Environment, Lands and Parks 1997). It is estimated that a sustained 1% decrease in stratospheric ozone results in a 2% increase in skin cancer cases (Environment Canada 1999).

For terrestrial animals, the incidence of eye and skin cancer similarly increases. More UV-B results in decreased growth, photosynthesis, and flowering for many agricultural and forest plant species. Furthermore, increased UV-B rays result in decreased productivity of phytoplankton, the first critical link in the marine food chain, affecting freshwater and marine plants. Early developmental stages of marine animals are also affected. Finally, increased UV-B rays on the earth's surface result in the faster degradation of many materials such as wood, plastic, rubber, and fabrics, requiring more frequent repairs and replacements (Ministry of Environment, Lands and Parks 1997).

The cause of ozone layer thinning is well understood. Naturally occurring ozone in the stratosphere is depleted through the action of synthetic compounds originally released on the earth's surface. Normally, ozone is both produced and destroyed in the stratosphere naturally, maintaining a constant concentration. However, these synthetic compounds release chlorine and bromine that react in ways that destroy ozone, resulting in greater ozone destruction than production. A single atom of chlorine, for example, can effectively destroy 100,000 ozone molecules or more before being destroyed itself (Ministry of Environment, Lands and Parks 1997). These synthetic compounds are commonly referred to as ozone depleting substances (ODS), and include chlorofluorocarbons (CFCs), halons (brominated fluorocarbons), hydrochlorofluorocarbons (HCFCs), and methyl bromide. CFCs account for 80% of the ozone depletion to date. ODSs have been used traditionally in air conditioners, refrigerators, foams, and solvents (Ministry of Environment, Lands and Parks 1997).

More recently, a link has been made between the thinning of the ozone layer and climate change. Many ODSs also act as greenhouse gases, trapping heat in the lower atmosphere. As a result, the higher atmosphere, where the ozone layer is most concentrated, becomes cooler. The complex reaction whereby ODSs destroy ozone is facilitated by cooler temperatures. Therefore, ODSs in the lower atmosphere acting as greenhouse gases facilitate the destruction of ozone by ODSs in the upper atmosphere. This is exacerbated by the fact that ozone itself is a greenhouse gas; less ozone in the ozone layer adds to the cooling effect, leading to the destruction of more ozone. Overall, the increase of greenhouse gases in the atmosphere effectively contributes to the thinning of the ozone layer (Environment Canada 1999).

Globally, there has been a decrease in the annual average amount of stratospheric ozone. Since 1979, the decrease has been 4-6% per decade at mid-latitudes. At higher southern latitudes, the decrease has been 10-12% per decade (Environment Canada 1999). The depletion has been greatest at the poles because of geographic and climatic factors. In 1995, the ozone layer over Antarctica declined by 60%; in 1997, the depletion over the Canadian Arctic was 45% below normal (Ministry of Environment, Lands and Parks 1997).

Being in the northern hemisphere, Canada has not experienced ozone depletions as dramatic as other countries. However, measurable changes have been noted. At the Saturna Island monitoring station near Vancouver, the ozone layer was depleted by an average of 8.9% in 1995 compared to pre-1980 levels (Ministry of Environment, Lands and parks 1997). Subsequent years have shown a less dramatic decrease in ozone levels; in 1997 the average depletion was 0.8% (Ministry of Environment, Lands and Parks 1998). The Saturna Island monitoring station is the only measurement point for ozone in the province.

Canada's consumption of new CFCs decreased by 96% between 1986 and 1996 (Ministry of Environment, Lands and Parks 1997). Nonetheless, because ozone is generated relatively slowly in the stratosphere, it will take decades to regenerate a normal ozone concentration even with a concerted global effort. It is estimated that the combined abundance of ODSs in the lower atmosphere peaked around 1994 and is now declining (Environment Canada 1999). However, the reactive by-products of ODSs are thought to be near or just at a peak now (Environment Canada 1999). Even if all

international commitments are met for ODSs, it is estimated that the ozone layer will not return to below critical levels until approximately 2060 (Ministry of Environment, Lands and Parks 1998). When other greenhouse gases are factored in, predictions about ozone layer recovery become less optimistic or certain.

Some government initiatives addressing this issue are listed in Appendix 4.

4.3.2 Impacts

The respondents' questionnaire results on the impacts of ozone depletion are similar to the impacts cited in the secondary literature summarized above. Impacts most commonly referenced are impacts on human health associated with increased rates of skin cancer, eye problems, and weakened immune systems. Impacts on the overall ecosystem such as reduced productivity and increased mortality rates are also cited by respondents.

While respondents rate the overall understanding of ozone impacts as moderate, they identify several areas where the impacts need to be better understood. The first is a better understanding of the health impacts, especially the less overt ones such as the impact on the immune system. The second is a better understanding of the impacts on ecological systems.

4.3.3 Monitoring

Respondents rate the adequacy of monitoring aspects of ozone depletion as moderate. The key gaps identified by respondents include better tracking of the impacts on flora and fauna, better tracking of the impacts on humans, more comprehensive UV monitoring and monitoring compliance with ODS regulations. The monitoring of ozone layer depletion appears to be adequate.

4.3.4 Causes

Respondents rate understanding of the causes of ozone depletion as very high, in fact the highest of the nine issues. Simply put, the cause is the release of ozone depleting substances into the atmosphere. No major gaps in understanding in this area are identified. However, there is still less than a complete understanding of the dynamics of changes in the ozone layer, particularly around the dynamics of the ozone layer recovery process.

4.3.5 Solutions

Respondents rate understanding of solutions to ozone depletion as high. Solutions identified by respondents include extension of the Montreal Protocol to more countries, the use of the precautionary principle in introduction of any new chemicals and stronger monitoring and enforcement of regulations in all countries.

4.3.6 Barriers to a solution

Respondents rate current efforts to mitigate ozone depletion as moderate. The only significant barriers identified by respondents are inadequate participation by other countries in the adoption and enforcement of regulations on ozone depleting chemicals and insufficient monitoring of compliance with regulations.

4.3.7 Knowledge gaps and research priorities

Overall, respondents rate understanding of all aspects of the ozone issue as moderate to high. The most significant knowledge gaps identified by respondents are a better understanding of impacts of ozone depletion on ecosystems and better monitoring of compliance and management of some ODS chemicals such as brominated compounds.

Recommended research priorities include evaluating the effectiveness of ODS regulations, the impacts of ozone depletion on species, continued research on the dynamics of the ozone layer and continued development of alternatives to ODS chemicals.

4.4 Air Quality

4.4.1 Overview

Air quality is an environmental issue as living organisms and non-living materials can be adversely affected by pollutants in the air. Some such pollutants are naturally occurring, such as wind-blown dust. However, most pollutants of concern are the result of human activity. Several important pollutants are sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide, hydrocarbons and ammonia. According to the Provincial Health Officer, the single most important outdoor air contaminant in BC is particulate matter that is 10 micrometres or smaller, referred to as PM10 (Ministry of Environment, Lands and Parks 1997). Some PM10, known as primary particulates, is discharged in the form of solid or liquid particles (other than pure water), such as dust, dirt, soot, and smoke. Other PM10, known as secondary particulates, is formed in the air when certain gases react. A subset of PM10 of particular concern for public health is PM2.5, that is, particulate matter that is 2.5 micrometres or smaller.

Air quality is a significant human health concern. Pollutants in the air are inhaled into the lungs and, in some cases, absorbed into the bloodstream. The greater the concentration of pollutants inhaled into the human body, the more difficult it is for natural defence systems to neutralize and remove these contaminants. PM10, and its subset PM2.5, are especially important in this regard as these particles can be inhaled deep into human lungs. As a result, there can be increased incidence of asthma, bronchitis, heart disease, and premature death, as well as restricted activity days for adults and missed school days for children. Based on available epidemiological evidence, it has been estimated that poor air quality accounts for 82 extra deaths, 146 extra hospitalisations, 283 extra emergency room visits, and 165,000 extra absences from school in British Columbia each year (Ministry of Environment, Lands and Parks 1997). In 1995, poor air quality was estimated to account for $1 billion of human health costs in the Fraser Valley (Ministry of Environment, Lands and Parks, 1995c). This is projected to rise to $1.5 billion by 2005 (Ministry of Environment, Lands and Parks 1995a).

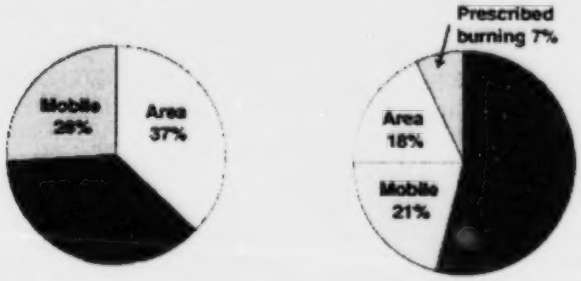
In addition to these human health impacts, there are further effects of poor air quality. These include damage to vegetation, reduced agriculture crop yields, damage to structures and building materials, damage to surface coatings such as paint, as well as impaired visibility (ARA Consulting Group Inc. and BOVAR-CONCORD Environmental 1994). Aesthetically, the smog caused by pollutants compromises the spectacular natural beauty of British Columbia. Recent evidence suggests that this has potential economic consequences related to tourism in addition to compromising the quality of life of residents.

Monitoring of air quality in BC is done primarily by the Ministry of Environment, Lands and Parks (MELP) and the Greater Vancouver Regional District (GVRD). MELP has 54 monitoring stations recording daily PM10 concentrations and 39 stations recording continuously for hourly averages for a number of contaminants. Of these 39 station, 20 record PM10 or PM2.5. The GVRD has 28 monitoring stations recording daily particulate concentrations and 24 stations recording continuously for hourly averages of a number of contaminants. Of these 24 stations, 14 record hourly particulate concentrations (Marsh 2000).

According to this monitoring data, more than 60% of monitored BC communities have been exposed to health risks from PM10 at least 5% of the time since 1994. Almost half of these communities exceeded this level more than 10% of the time in 1998 (Ministry of Environment, Lands and Parks 2000). The lowest concentrations of PM10 are found in the southwest corner of the province, whereas the more frequent and highest concentrations of PM10 are measured in the Interior (Ministry of Environment, Lands and Parks 1997).

As illustrated in Figure 22, sources of PM10 in the province differ significantly within and outside the Lower Mainland. Within the Lower Mainland, point sources such as bulk shipping terminals and forest processing facilities, account for 37% of primary PM10, as do area sources such as private residences and agriculture. Mobile sources, such as cars, account for the remaining 26%. Outside the Lower Mainland, point sources account for 54% of primary PM10, the majority of which are beehive burners and pulp and paper processing facilities. Area sources, primarily residential wood heating, account for 18% of total emissions, while mobile sources contribute 21% and prescribed burning, the remaining 7% (Ministry of Environment, Lands and Parks 2000).

Figure 22 Sources of primary particulates inside and outside Lower Mainland



Lower Mainland Outside Lower Mainland

(Ministry of Environment, Lands and Parks 2000)

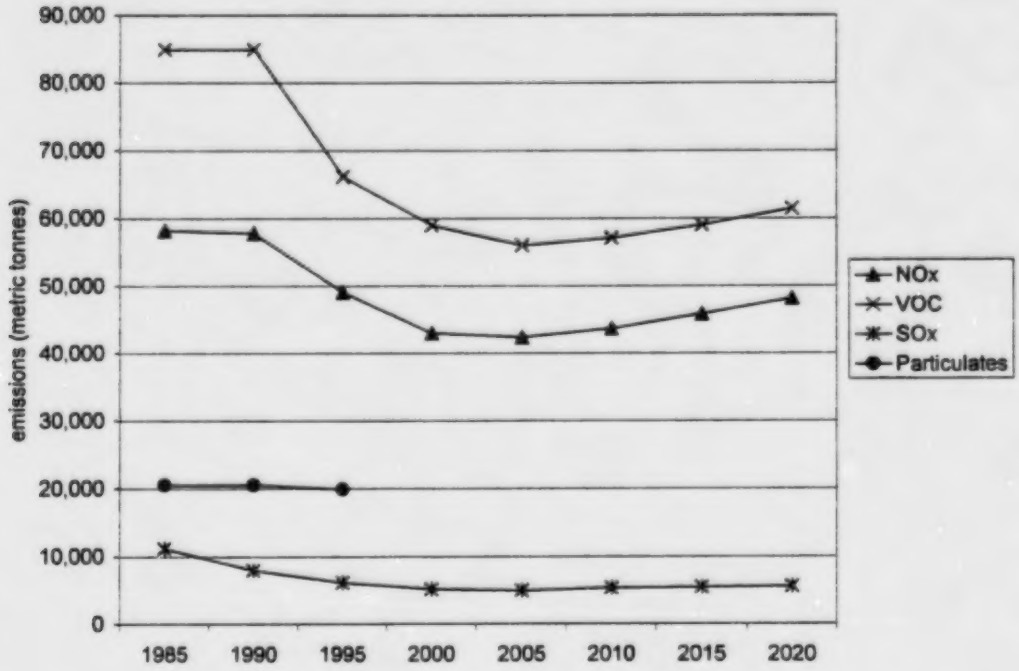
Secondary particulates, that is, particulates not directly discharged but formed by a chemical reaction of gases in the air, may account for as much as half of the very fine PM10 particles in the Lower

Fraser Valley during summer months. Such gases include SO_2, NO_x, hydrocarbons, and ammonia. Sources of these gases include cement and petroleum industries, marine vessels, motor vehicles, solvent usage, vegetation, and agriculture (Ministry of Environment, Lands and Parks 1997).

Figures 23 and 24 illustrate the tonnes of air pollutants emitted in the Lower Fraser Valley historically and as projected for the future.

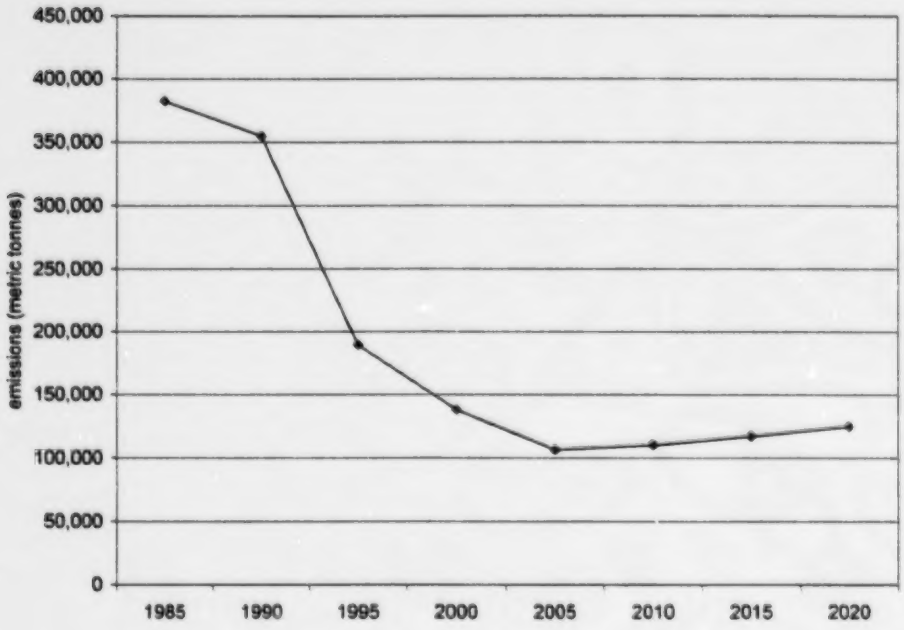
Some government initiatives addressing this issue are listed in Appendix 4.

Figure 23 NOx, VOC, SOx, and particulate emissions in the Lower Fraser Valley – historic and projected[1]



(Levelton 1998 and Alchemy Consulting Inc. and Levelton Engineering 2000)

Figure 24 CO emissions in the Lower Fraser Valley – historic and projected[2]



(Levelton 1998 and Alchemy Consulting Inc. and Levelton Engineering 2000)

4.4.2 Impacts

Respondents rate the understanding of impacts of air pollution one of the highest of any of the nine environmental issues. Their responses confirm the secondary literature summary of impacts cited above, including human health effects, lower productivity in resource-based industries such as agriculture, and lower aesthetic attractiveness which in turn impairs tourism and immigration of skilled labour. One area where there is still an important gap is the understanding of the relative significance of the different contaminants such as PM 2.5 on human health at different contamination levels.

4.4.3 Monitoring

Although respondents rate the adequacy of air quality monitoring the highest of the nine issues, it still receives only a moderately adequate rating. The key gaps are inadequate monitoring of PM 10 and PM 2.5 -- which are among the most serious air contaminants -- inadequate monitoring outside the GVRD, and overall poor data management.

4.4.4 Causes

Respondents rate understanding causes of air pollution as very high. The clear documentation of sources of air pollution from transportation and industrial sources summarized above attests to this. An area where there is still some uncertainty is the relative contribution of various sources to PM 10 and PM 2.5 contamination.

4.4.5 Solutions

Again respondents rate understanding of solutions to air pollution as high. Feasible technology exists for significantly reducing automobile emissions and emissions from point sources such as beehive burners and other industrial activities. The task is to ensure adoption of these technologies by a combination of tougher regulations and incentives and to reduce the overall use of the single occupancy automobile, by improved transit and land-use planning, and by green taxes. The cost-effectiveness of various measures also needs careful assessment so that implementation priorities can be appropriately set.

4.4.6 Barriers to a solution

Respondents rate current efforts to mitigate air pollution second highest among the nine environmental problems. Nonetheless, the overall rating of 4.75 is poor -- there is still a significant gap between knowledge and action which could lead to a decline in air quality over the next several decades unless additional measures are undertaken.

The two key barriers cited by respondents are the anticipated costs of implementing abatement measures and lack of leadership combined with lack of public support for tax-shifting measures such as increasing costs for driving. The recent controversy over the transit levy in the Lower Mainland is a case in point. Additional barriers mentioned less frequently by respondents include limited public understanding of impacts of air pollution, especially outside the Lower Mainland, and an excessive reliance on the automobile which is hard to change in the short run.

4.4.7 Knowledge gaps and research priorities

The key knowledge gap identified by respondents is the impact of air quality on human health. Although human health impacts are understood at a general level, the understanding of impacts of different levels of air pollution and the relative contribution of different contaminants needs to be improved to set acceptable air quality standards. Other knowledge gaps identified by respondents include understanding specific regional airsheds to determine the relation between emissions and air quality, understanding how to successfully implement the required policy changes, and perfecting zero emission technology such as electric cars and fuel cells.

Research priorities identified by the respondents closely follow from these knowledge gaps. They include health research assessing the impacts of air pollution, airshed analysis to understand the relationship between emissions and air quality, and policy research to assess the cost-effectiveness of alternative mitigation measures and to identify effective implementation strategies.

4.5 Water Resource Management

4.5.1 Overview

Issues of water resource management tend to relate to water quality and/or water quantity. Water quality pertains to the physical characteristics of the water, such as the concentration of contaminants, as well as naturally occurring characteristics such as pH and dissolved oxygen concentration. Water quantity relates to how fresh water moves through the hydrological cycle, is transported through river and groundwater systems to estuaries, and is used or consumed along this cycle. When discussing water management, a distinction is often made between surface water -- water on the surface of the ground -- and groundwater, which is found in the ground between soil particles. Nonetheless, the two are inextricably linked, with one always originating from or recharging the other.

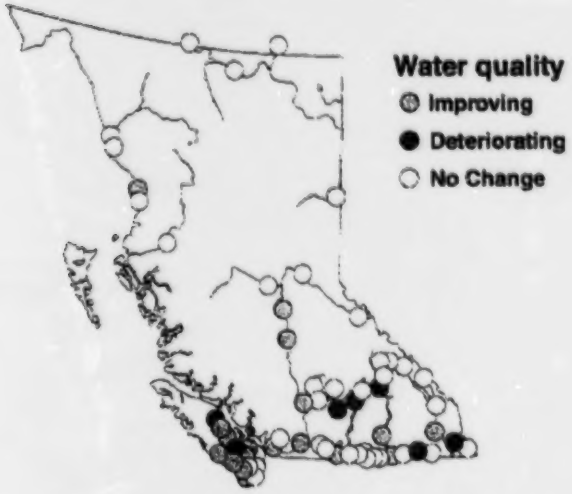
Poor water quality can have a number of negative impacts. Drinking water quality and human health can be affected. Fish, shellfish, and other aquatic organisms can be compromised, killed, or made unfit for human consumption by poor water quality. Similarly, commercial fisheries, aquaculture, and First Nations' use of fish for food can be negatively impacted. Recreation, tourism, general aesthetics, and even real estate values can be compromised by poor water quality.

There are a number of pollutants that commonly impact water quality. Pathogens in the water can cause gastrointestinal diseases, ear infections, and skin diseases in humans. Oxygen-depleting substances reduce the oxygen available for aquatic organisms, stressing those organisms. Nutrients such as nitrogen and phosphorus can lead to algal blooms in surface water bodies, as well as render water unsuitable for human consumption. Sediments in the water can affect the ability of aquatic organisms to survive in water, as well as impact the aesthetic value of drinking water. Toxins in the water impact all life forms dependent on that water (Ministry of Environment, Lands and Parks 1998a).

There are many sources of water pollution, often separated into point sources and non-point sources. Point sources discharge pollutants to water from a specific, identifiable location, and include industrial discharges, and municipal sewage treatment system discharges. Non-point sources are more diverse and not as easily connected to the resulting pollution. Non-point sources of pollution include stormwater run-off and combined sewer overflows (toxins, pathogens, nutrients), agriculture (pathogens, nutrients, sediments), on-site sewage systems (nutrients, pathogens), forestry practices (sediments, nutrients, toxins), land development (sediments, toxics, pathogens), and marine activities (nutrients). Even the atmospheric deposition of a number of non-point source emissions, such as motor vehicle emissions, can result in poor water quality (Ministry of Environment, Lands and Parks 1998a).

According to monitoring data, water quality in British Columbia is generally good, although there are a number of areas with localized pollution. Water quality is only monitored in areas where there are likely to be water quality concerns; there are thousands of water bodies in British Columbia that are not monitored. Of 124 water bodies monitored between 1987 to 1993, approximately half were rated fair, and 9 were rated as borderline or poor (Ministry of Environment, Lands and Parks, 1998b). In 1997, only 16 water bodies were monitored. Water quality is poorest in highly populated areas, such as the Georgia depression and Southern Interior. Since 1985 when trends in water quality monitoring started, water quality has improved in 29% of monitored water bodies, remained the same in 60%, and deteriorated in 11%. These trends in water quality are illustrated in Figure 25 (Ministry of Environment, Lands and Parks 2000).

Figure 25 Trends in surface water quality in BC

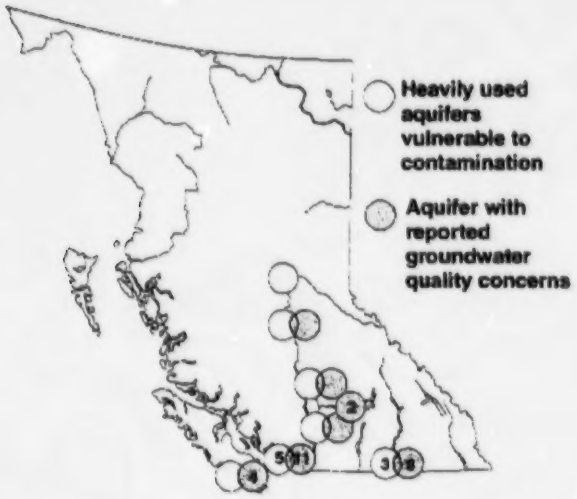


(Ministry of Environment, Lands and Parks 2000)

Groundwater is an important source of water for approximately 750,000 BC residents. Outside of the Greater Vancouver and Victoria areas, groundwater supplies approximately 25% of total municipal water demand (Ministry of Environment, Lands and Parks 2000). Groundwater also contributes to the year-round flow of water in fish-bearing streams and wetland habitat. Contamination of groundwater can occur through poor well construction, pollution on the surface, or by salt water intrusion in coastal areas. Groundwater issues can also arise related to interference in water extraction between nearby wells and conflicts between surface and groundwater users.

Groundwater conditions are monitored in 150 observation wells throughout BC. Although 56% of wells were showing declining levels in 1980, this situation has since improved as groundwater levels were naturally recharged. Because no licence is required for groundwater extraction, there are few data available regarding the volume of groundwater extracted. An inventory of 296 aquifers in BC has been developed to assess risks to groundwater quantity and quality. There are concerns regarding some of these aquifers, as illustrated in Figure 26. Twenty-six of these, located primarily in the Fraser Valley, east coast of Vancouver Island, and the Southern Interior, have been classified as heavily used, posing a risk to groundwater quality. Specific sites within 28 aquifers have health-related water quality concerns, primarily related to nutrient concentrations (Ministry of Environment, Lands and Parks 2000).

Figure 26 BC groundwater aquifers of concern



(Ministry of Environment, Lands and Parks 2000)

A further aspect of water resource management in BC is flood hazard management. A number of areas of the province are subject to flooding along major waterways. Among these, a Fraser River flood potentially poses the greatest danger. It is estimated that there is a one in three chance that a flood at least as severe as the 1894 flood will occur in the next 60 years. In 1994, it was estimated that should the dyke system fail for such a flood, the flood damages alone would amount to $1.8 billion (1994$) (Fraser Basin Management Program, 1996). Between 1989 and 1991, $90 million was spent repairing infrastructure and building protective works in the Lower Mainland, Squamish and Penticton areas. To date, there are 117 dyking systems with 890 km of dykes in British Columbia (Ministry of Environment, Lands and Parks, 1993).

Some government initiatives addressing this issue are listed in Appendix 4.

4.5.2 Impacts

Respondents rate the understanding of impacts of water issues as moderate. The impacts cited by respondents are consistent with the review of the secondary literature summarized above. Direct impacts on humans result from three problems; contamination of drinking water from both surface and groundwater sources, potential flooding aggravated by climatic change, and impeded recreational opportunities. Direct impacts on flora and fauna result form contamination of surface water, changing water temperatures and changes in hydrological cycles. Potential water shortage in some regions is also an issue cited by respondents.

4.5.3 Monitoring

Respondents rate the monitoring of water issues as poor. The principal problems cited by respondents are inadequate monitoring of water quality due to government cutbacks and poor integration and management of the data that is collected. Monitoring is viewed by respondents as inadequate in several ways. Not enough water bodies are monitored and those that are monitored are not monitored frequently enough and for the right parameters.

4.5.4 Causes

Respondents rate the understanding of causes as high. The most common cause cited by respondents is inadequate legislation and policy. The three key deficiencies cited are lack of a comprehensive legislative framework, especially for groundwater; lack of integrated watershed planning; and the failure to adjust the management regime from one focused on point sources, which are largely resolved, to non-point sources which are more complex to manage. These policy weaknesses, combined with continued population growth and intensification of agricultural and forestry activities, are the major cause of water problems.

4.5.5 Solutions

Respondents rate understanding of solutions to water problems as moderately high. One area for improvement identified by respondents is a stronger legislative framework to protect drinking water (especially groundwater), setting clear standards, providing for strong enforcement of the standards, and designating a lead agency for protecting drinking water. Reforming the *Waste Management Act* to focus on pollution prevention instead of end-of-pipe management is also recommended. Legislative reform for ensuring the protection of ecological integrity, including other water users such as fish, is also mentioned.

A new management approach based on integrated watershed planning similar to the land-use planning under CORE is proposed by some respondents to accompany the legislative changes. The source of water pollution has changed from point sources which are now relatively well managed to non-point sources which are more difficult to manage because of their diverse nature. Non-point sources require a different management regime based more on education than regulation. Some respondents propose implementation of the Ministry of Environment's current non-point strategy as an effective way of managing non-point pollution.

Better monitoring, full cost accounting, and pricing and promotion of innovative green technologies are also recommended.

4.5.6 Barriers to a solution

Respondents rate current efforts to manage water issues as low. The gap between knowledge of solutions and implementation of solutions is rated as high. Key barriers impeding better management of water cited by respondents include lack of a legislative framework, increased challenges of managing non-point as opposed to point sources of pollution, economic costs of mitigative measures, and poor public understanding of the issues involved.

4.5.7 Knowledge gaps and research priorities

Principal knowledge gaps identified by respondents include understanding human health impacts of contaminant levels, understanding impacts of contaminant levels on the ecological system, assessing effectiveness of restoration programs, effective implementation of policy changes such as full cost accounting, and comprehensive monitoring to assess water quality.

Research priorities include basic scientific research to improve understanding of human health and ecosystem impacts of contaminants, evaluation of watershed restoration programs, development of an effective monitoring and data management system, and policy research on effective implementation.

4.6 Biodiversity

4.6.1 Overview

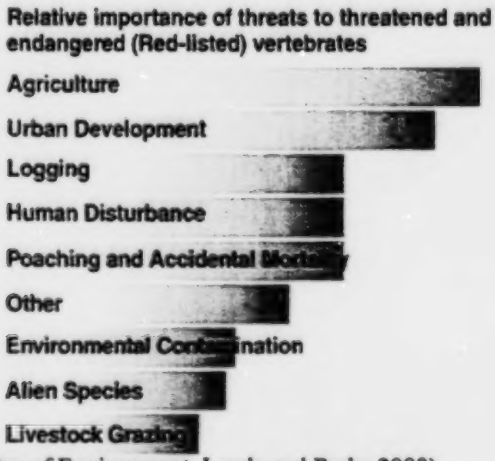
The term biodiversity is an abbreviation of biological diversity, "the variability among living organisms from all sources including, among others, terrestrial, marine, and other aquatic ecosystems, and the ecological complexes of which they are part" (Environment Canada 1996). Biodiversity refers to several layers of biological diversity. The first is diversity within species, or genetic diversity. This is the extent of variation found in gene pools of individual species. The greater the genetic variability, the greater the chance that a given species will be able to survive and adapt to changing environmental conditions. The second layer of biodiversity is the variation between different species. To date, 1.5 million different species have been scientifically described on earth; the total number of species may be 5 to 100 million. In Canada, it is estimated there are currently over 135,000 species. The third layer of biodiversity is the diversity of ecosystems and ecological processes. This reflects the number of different ecosystems, the variation between and extent of these systems, as well as the ecological processes sustaining these systems (Environment Canada 1996).

The worldwide decline of biodiversity is an issue of international importance. Although biodiversity has naturally fluctuated over millions of years, the current rate of species extinctions is estimated to be 1,000 to 10,000 times the rate in any previous period. Up to two thirds of all living species may face extinction within this century (Environment Canada 1996).

Declining biodiversity has a number of serious impacts. Perhaps most importantly, biodiversity is a measure of the health of ecological processes on earth, processes which provide critical, life sustaining services. For example, the biosphere harnesses solar energy into plants and other living materials, providing the basis for all food chains. Further services include oxygen production, water purification, and climate moderation. Declining biodiversity is also important in that it represents the loss of species with unknown ecological, economic and medical importance. For example, the future discovery of medicines like the cancer drug Taxol, recently developed from the Pacific Yew in Canada's coastal forests, is compromised by reduced biodiversity (Environment Canada 1996). Biodiversity is also important in that it provides and/or supports employment of farmers, foresters, fishers, as well as providing economic value through ecotourism. Furthermore, many indigenous people have a cultural relationship with nature and depend on biodiversity to provide them with food and income.

The current declines in biodiversity are caused to some extent by natural phenomena, such as forest fires, volcanoes and drought. However, human activities account for the majority of changes, as illustrated in Figure 27.

Figure 27 Relative importance of threats to threatened and endangered (Red-listed) species



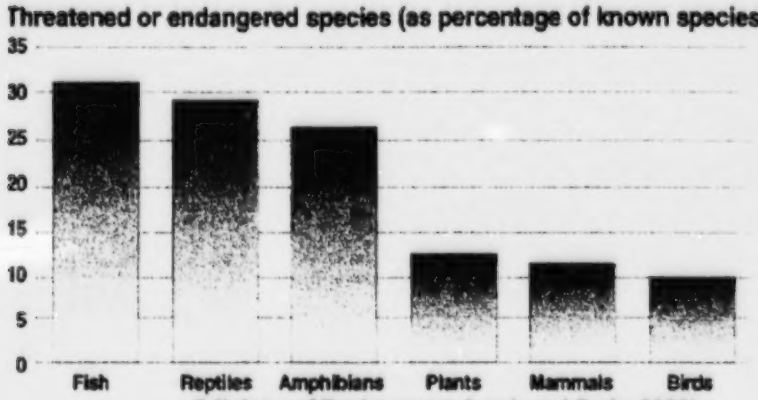
(Ministry of Environment, Lands and Parks 2000)

Humans have compromised or destroyed habitat that supports many plant and animal species by building houses, expanding industrial sites, extracting raw materials, clearing land for agriculture, logging forests, and draining wetlands. The populations of some species have been directly reduced through poaching and overharvesting. Humans have also introduced a number of alien species into new habitats, species that compete with indigenous species for limited resources. For example, of the 3,137 species of vascular plants that grow wild in British Columbia, it is estimated that 21% are alien species (Environment Canada 1996).

British Columbia, being Canada's most biologically diverse province, has a rich biodiversity heritage to protect. By the end of 1999, 11.4% of BC's land base was dedicated to protected areas (Ministry of Environment, Lands and Parks 2000).

For the known species in BC, 12% of the vascular plants and 15% of the vertebrate animals are considered either threatened or endangered (Ministry of Environment, Lands and Parks 2000). The percentage of threatened or endangered species is shown in Figure 28.

Figure 28 Threatened or endangered species (as percentage of known species)



(Ministry of Environment, Lands and Parks 2000)

Some government initiatives addressing this issue are listed in Appendix 4.

4.6.2 Impacts

Loss of biodiversity is ranked by respondents as one of the most serious environmental problems in British Columbia The impacts cited by respondents include loss of genetic diversity, ecosystem simplification and weakened resilience and integrity of ecosystems, and potential threats to human health. Overall, however, respondents rate understanding of these impacts as relatively poor, in part because of poor understanding of ecosystem dynamics.

4.6.3 Monitoring

Respondents rate the adequacy of monitoring biodiversity issues as low. Inventory data on key species such as grizzly bears could be improved and inventory for non-mega species is poor. Good trend line data necessary for analysis of biodiversity is unavailable and existing information is not easy to access or analyze because it is collected by different agencies in different formats.

4.6.4 Causes

Respondents rate understanding of the causes of biodiversity and habitat loss as moderate. Urbanization, logging, hunting and agriculture are all identified as major threats. The lack of a legislative framework to protect biodiversity and endangered species and the economic impacts of forgone resource extraction are also cited by respondents as major causes. The fact that biodiversity loss does not have as direct or readily observable an effect on humans as air pollution or water quality also reduces public understanding and pressure for biodiversity protection.

4.6.5 Solutions

Respondents rate understanding of how to protect biodiversity and habitat as moderate. Knowledge of habitat requirements for specific species, impacts of land-use activities, and alternative resource harvesting techniques, particularly in logging, need to be improved.

Measures proposed by respondents include a stronger legislative basis for protecting habitat, which includes protection for all levels of biodiversity, incentives such as tax reductions for maintaining land in its natural state (as well as strongly enforced regulations), independent scientific determination of species at risk, and protection plans. Public input at all stages is also recommended.

Faster implementation of the land-use planning provisions in the Forest Practices Code, completion of the land-use plans for British Columbia, increase in protected areas beyond 12 % with special wildlife protection sanctuaries, creation of marine protected areas, increased public education, and improved inventory are all recommended by respondents.

4.6.6 Barriers to a solution

Respondents rate current efforts to protect biodiversity as poor. The key barriers identified by respondents include economic costs of increased protection, lack of public understanding and support, and resistance from various stakeholders in the resource sector.

4.6.7 Knowledge gaps and research priorities

The key knowledge gaps identified by respondents are inventory and monitoring of species and understanding species' habitat needs adequately. Research priorities identified are better monitoring and inventory information, understanding of habitat requirements, better understanding of impacts of alternative resource harvesting techniques, and evaluating effectiveness of recovery and rehabilitation strategies.

4.7 Fish Resource Management

4.7.1 Overview

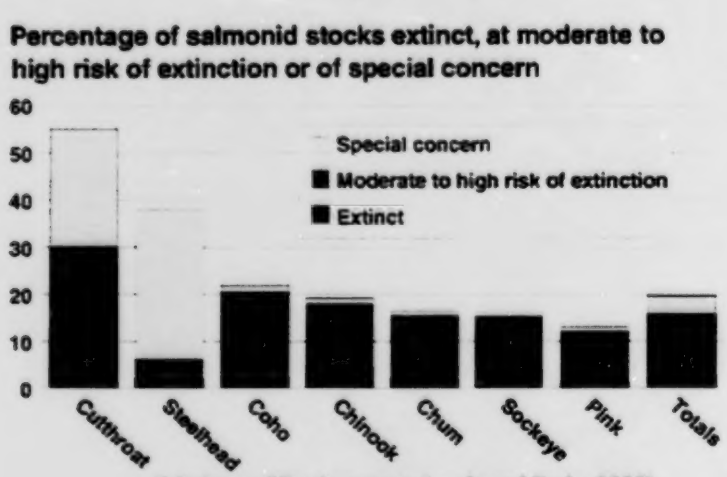
Historically, fish resources have played an important role in British Columbia. Fish have sustained aboriginal peoples for centuries, and supported commercial and recreational fisheries since the 1830s. The commercial fishery sector, from aquaculture through to fish processing, employs over 20,000 British Columbians in full and part-time positions (Ministry of Environment, Lands and Parks 1999). BC is also world famous for its unique recreational fishery, which attracts over 800,000 residents and tourists each year (Fisheries Renewal BC 1998). The four key components of BC fisheries – commercial fishing, sport fishing, aquaculture, and fish processing – contribute more than $2 billion in revenues to the provincial economy and account for more than $900 million in GDP annually (BC Fisheries 2000).

In addition to these direct human benefits of employment and economics, fish are also an important part of BC's natural ecosystems. Fish are a key food source for top predators such as grizzly bears, killer whales, seals, sea lions, and bald eagles (Ministry of Environment, Lands and Park 1993). Fish also play a cultural role in BC; wild fish are part of what makes up "Beautiful British Columbia" and, as such, have an inherent value.

In British Columbia, many fish stocks are healthy. Of the 5,476 salmon stocks for which there is data, over 80% are healthy (Ministry of Environment, Lands and Parks 1998). BC's halibut and black cod fisheries are very prosperous, and the herring stocks have been rebuilt to healthy levels since the 1960s collapse (Walters 1995).

However, some BC stocks are declining. Of the same 5,476 salmon stocks, 3% are extinct and 13% are at moderate to high risk of extinction. Furthermore, 13% of cutthroat trout are extinct, while 18% of coho and 13% of chinook stocks are at moderate to high risk of extinction, as illustrated in Figure 29. In 1999, the ocean survival of the Fraser River sockeye was so low that the fishery had to be closed. Similarly, the Rivers and Smith Inlet sockeye fisheries have been closed since 1996 and 1997, respectively (Pacific Fisheries Resource Conservation Council 2000). Although many stocks are healthy, the loss of genetic diversity with declining stocks threatens the long-term sustainability of salmon in BC (Ministry of Environment, Lands and Parks 2000).

Figure 29 Percentage of salmonid stock extinct, at moderate to high risk of extinction or of special concern



(Ministry of Environment, Lands and Parks 2000).

In addition to declining salmon stocks, white sturgeon stocks of the Fraser River have been nearly destroyed by overfishing, to the point of making it an endangered species. Stream-spawning Kokanee in Okanagan Lake have declined 98% since 1971; the lake has been closed to angling since 1995 (Ministry of Environment, Lands and Parks 2000).

The monitoring data available for BC's fish resource is not comprehensive. The status of 43% of the salmon stocks and 80% of cutthroat trout in BC is unknown. Of all the unknown fish stocks, a further 22% may be at high risk or extinct (Ministry of Environment, Lands and Parks 1998).

There are a number of pressures on the fish resource that may contribute to such declining populations. One of these pressures is the loss of spawning and rearing habitat due to human activities such as logging and urban development. Habitat can be compromised or destroyed as a side effect of such activities, resulting in fewer healthy fish stocks. For example, much of the Georgia Strait coho that previously spawned in about 100 streams now emerge from only about 20 streams and hatcheries (Walters 1995).

A further pressure on the fish resource is overfishing. Where more fish are harvested than can be produced, fish populations naturally decline. As a result of overfishing, several stocks have been severely impacted in the past. For example, following several years of intensive harvesting, the abalone fishery was closed over the entire west coast in an attempt to restore the populations (Walters 1995).

Climate change is thought to have as large an impact on salmon populations as the fish harvesting effort (Glavin 1998). Climate change may lead to large-scale disturbances in marine ecosystems, changing river temperatures and flow regimes, affecting fish survival and migration patterns. Some experts are of the opinion that no one should underestimate the seriousness of climate change issues for salmon (Pacific Fisheries Resource Conservation Council 2000).

Hydropower developments add further pressures to fish resources, impeding the ability of fish to move up and down river systems. Water pollution and reduced water flows due to development have also increased the stress of fish in that habitat (Ministry of Environment, Lands and Parks 1998).

Some experts are of the opinion that hatcheries can be a further stress on existing wild fish stocks (Walters 1995). In hatcheries, wild fish eggs are hatched in a contained, controlled environment and introduced into rivers and lakes as small fish. Depending on how the fish culture program is managed, these fish can then compete with fish hatched in the wild for limited resources, reducing the overall genetic variability.

Open net-pen aquaculture can also be considered part of the stresses on wild fish stocks. These forms of aquaculture can introduce antibiotics, food wastes, and fish wastes into the water immediately surrounding ocean pens, stressing wild populations. Furthermore, the Atlantic salmon reared in aquaculture pens are thought by some to escape the nets of the fish farms and successfully compete with wild Pacific salmon stocks in BC's rivers and streams.

Some government initiatives addressing this issue are listed in Appendix 4.

4.7.2 Impacts

The protection of fisheries is rated by respondents as the most serious environmental issue in British Columbia. Our understanding of the impacts is rated as moderate. The major impact is the potential extinction of many of the fish species, which in turn will have significant repercussions for coastal communities through loss of direct fisheries jobs and loss of tourism jobs. The loss of fisheries will also impact other components of the ecosystem by reducing nutrient flows in watersheds and stressing other species such as whales and grizzly bears which depend on fish for food.

4.7.3 Monitoring

Respondents rate overall monitoring of fish-related issues as poor. The key gap in monitoring identified by respondents is the lack of basic stock assessment data on a number of species. Another gap is inadequate monitoring of impacts of potential threats to fisheries such as forestry, energy development, aquaculture, water quality, and climatic change.

4.7.4 Causes

Although respondents rate understanding of causes of fisheries problems the lowest of the nine environmental issues, it still gets a moderate rating of 5.42 on the 1 to 10 scale. At a general level respondents identify the causes of fisheries problems as overharvesting, climate change, habitat loss from resource use such as forestry and energy development, and to a lesser extent fish farming. Underlying threats are institutional problems such as the common property nature of the fisheries, conflict between competing users of fish and fisheries habitat, and jurisdictional disputes between different governments.

Although there is a good understanding of these causes at a general level, respondents conclude that there is not a good understanding of the relative importance of these different threats.

4.7.5 Solutions

Respondents rate understanding of solutions to fisheries problems as a moderate 5.63 on the 1 to 10 scale. Solutions identified by respondents follow logically from the causes summarized above. Solutions include reducing the catch to sustainable levels based on a precautionary approach, protecting habitat by stronger riparian measures on urban and resource development, providing stronger protection of water requirements for fish in the water allocation process, reducing water pollution, and better monitoring of fish stocks. Respondents also emphasize the need for increased cooperation among the various stakeholders.

4.7.6 Barriers to a solution

Respondents rate current efforts to protect fish as poor. The key barriers respondents identify include lack of a sound legislative basis for protecting fish, lack of monitoring data, and lack of leadership to address tradeoffs and achieve cooperation among stakeholders. Lack of scientific understanding of the relative significance of threats and the health of various stocks is also cited as a barrier.

4.7.7 Knowledge gaps and research priorities

The key knowledge gaps identified by respondents are inadequate understanding of the relative impacts of threats, inadequate assessment of many of the fisheries stocks, and poor understanding of impacts of habitat restoration programs.

One recommended research priority is better understanding of the relative importance of threats such as climate change, habitat loss, and overfishing. Other research priorities include better inventory, better stock assessment, and analysis of the effectiveness of alternative management policies.

4.8 Forest Resource Management

4.8.1 Overview

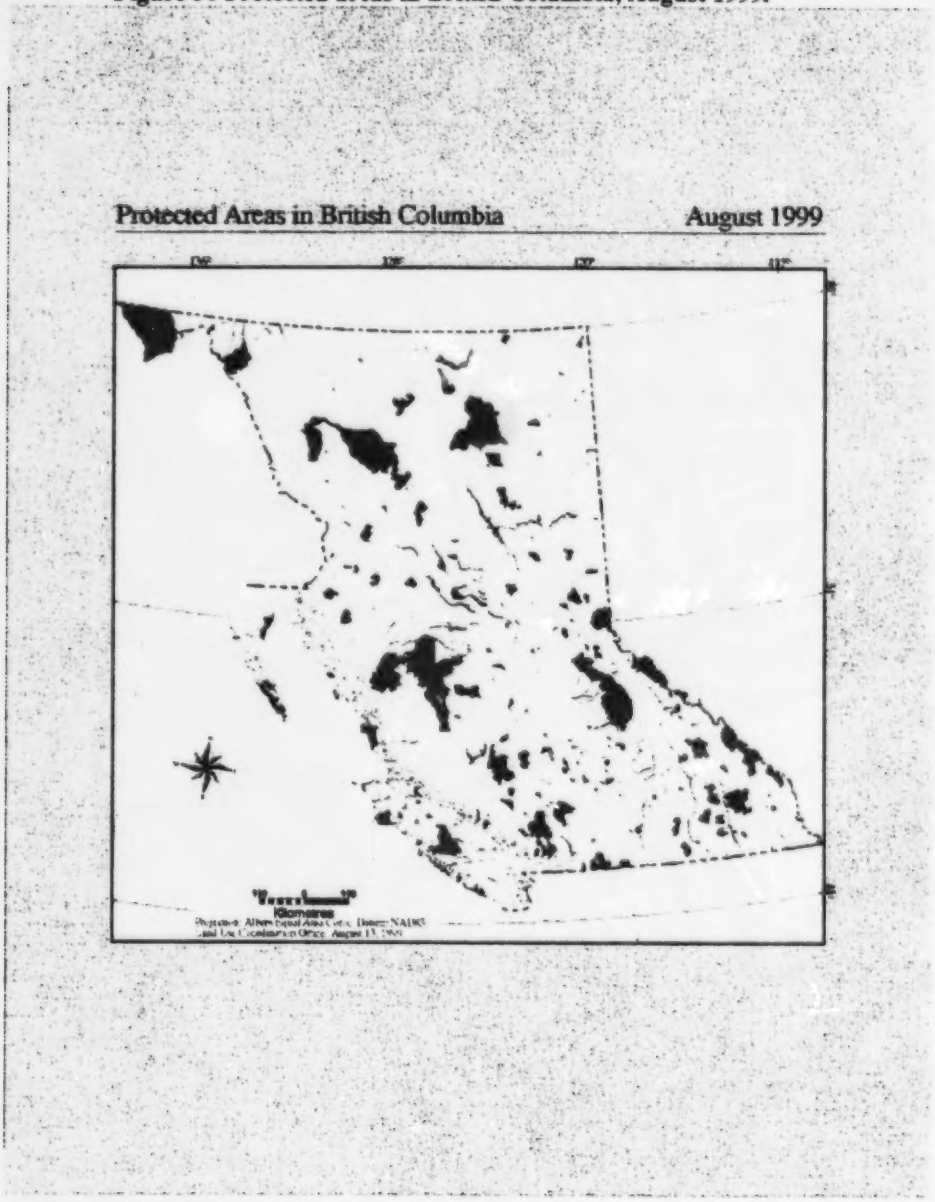
Of the 95 million hectares that constitute the landmass of British Columbia, 59 million hectares (62%) are forest land. Within this large area, there is a wide range of ecosystems and dominant tree species. The province can be divided into 14 unique biogeoclimatic ecosystems based on the prominent plant species, soil types, and climate. The coastal forests are typically much older than those found in the Interior. It is estimated that 41% to 55% of the forests on the coast are over 250 years old. In the Interior, 6% to 25% of forests are over 250 years old, whereas 54% are 120 years or younger (Ministry of Environment, Lands and Parks and Environment Canada 1993; Marchak, Aycock and Herbert 1999). Just under 43% of all forest land in BC is old growth[3] (Marchak, Aycock and Herbert 1999).

Forests can be disturbed by a number of natural factors such as wildfire, wind storms, landslides, insects and disease. Human disturbances include logging and, to a much lesser extent, land clearing for agriculture and urban development. These disturbances have different significance and effects on the coast and in the Interior. In this century, insects, wildfire and logging have disturbed the largest areas of forests throughout BC. Since the 1960s, the number of wild forest fires has decreased dramatically due to a forest fire suppression effort, saving millions of cubic metres of wood for industrial use. In recent years, this effort is considered to have resulted in forests at a greater risk to insects and disease, especially in the Southern Interior (Ministry of Environment, Lands and Parks and Environment Canada 1993).

Of BC's forest land, 95% is publicly owned while the remaining 5% is private land. Of the 59 million hectares of forest land, about 23 million hectares (~40%) are considered suitable and available for harvest (Ministry of Forests 1996). The remaining 60% is protected, inoperable, or reserved from harvesting to protect ecological values (Ministry of Forests 1999).

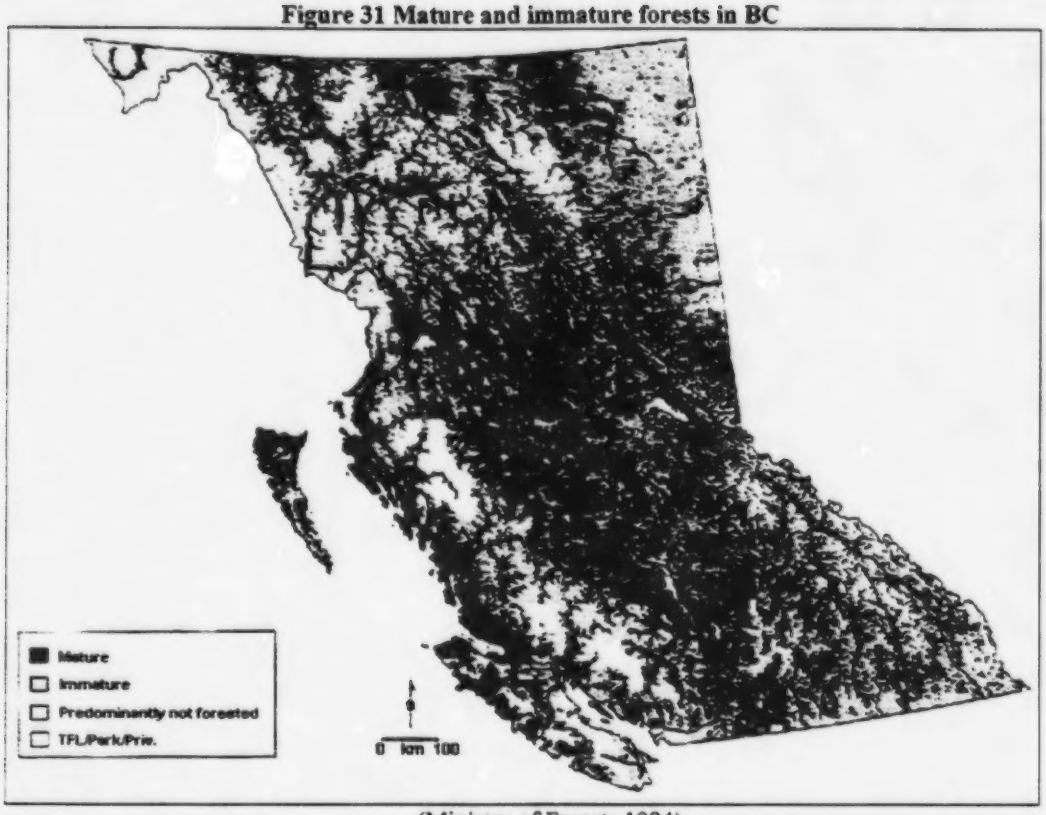
Almost half (29 million) of BC's 59 million hectares of forest land supports forests more than 120 years old that have never been harvested (Ministry of Forests 1996). As of October 1997, about 13% of BC's old growth was in protected areas (Marchak, Aycock and Herbert 1999). Figure 30 illustrates the locations of protected areas in BC. The remaining 30 million hectares of forest land in BC support young forests, including the 9.2 million hectares of land harvested since logging began (~15% of forest area in BC) (Ministry of Forests 1996). Figure 31 illustrates the location of mature and immature forests in British Columbia[4].

Figure 30 Protected areas in British Columbia, August 1999.



(Land Use Coordination Office 1999)

Figure 31 Mature and immature forests in BC



(Ministry of Forests 1994)

Section 8 of the *Forest Act* requires BC's Chief Forester to reassess the annual allowable cut (AAC) for forest land within Timber Supply Areas (TSAs) and Tree Farm Licences (TFLs) every 5 years. The AAC is the volume of timber that may be harvested and is set separately for each of the 37 TSAs and 34 TFLs in the province. In determining the AAC, the Chief Forester must consider not only the use and characteristics of the forests, but the government's economic and social objectives as well (Ministry of Forests 1996). Between 1981 and 1997, an average of approximately 200,000 hectares per year have been harvested annually, which amounts to an annual rate of less than 1% of the area available for harvesting (Ministry of Forests 2000).

Although the AAC is taken from a relatively small percent of the forest land area, it is higher than what the Ministry of Forests has projected to be the long-term sustainable harvest level in many TSAs. The average difference between the Ministry's estimate of long-term sustainable harvest levels and the current AAC for the entire province is 21% (Townsend 2000). This is partially because trees harvested in the future will increasingly be taken from second-growth forests which are thought to yield less volume of timber per hectare than today's old growth forests. Secondly, forests are increasingly managed for the full range of forest values, such as biodiversity, fish, and water quality, instead of just for timber values. In order to protect these other values, less timber can be taken from the same land area than if these values were not considered (Ministry of Forests 1996). Long-term sustainable harvest level projections are made with considerable uncertainty, projecting on average 80 years into the future. Based on new studies, a higher than anticipated growth rate in second growth stands may increase the long-term sustainable harvest levels (Townsend 2000).

The forest sector in BC provides over half of the provincial export revenues (Ministry of Forests 1999) – in 1995, exports were almost $17 billion (Ministry of Forests 1996). The forest industry employs 6% of BC's labour force (Ministry of Forests 1999); including indirect employment, this value climbs to 15% (Ministry of Forests 1996).

Some government initiatives addressing this issue are listed in Appendix 4.

4.8.2 Impacts

Respondents rate understanding impacts of forestry as high. Impacts identified by respondents include loss of habitat and biodiversity, negative impacts on water quality, and socioeconomic impacts of reduced harvesting levels. Respondents also highlight a trade-off between impacts on short run economic objectives of maintaining high rates of harvest and low costs of production versus impacts on long run sustainability and protection of non-timber values.

4.8.3 Monitoring

Respondents rate monitoring of forestry issues as poor. Key gaps are inadequate monitoring of impacts of logging on the ecosystem and inadequate inventory of non-timber values.

4.8.4 Causes

Respondents rate understanding causes of forest-related problems as high. Government management practices are cited as the primary cause of forestry-related problems. Too high a rate of harvest, an industrial based tenure system, slow implementation of key planning components of the FPC, and inadequate emphasis on non-timber values are all cited.

4.8.5 Solutions

Respondents rate knowledge of solutions as moderate. Solutions proposed by respondents are similar to those proposed to protect biodiversity: faster implementation of the planning provisions of the FPC, completion of the land-use planning process for the province, tenure reform to increase community control, increased value-added, full cost accounting, and more environmentally sensitive logging practices. The primary theme in most of these recommendations is integration of stronger ecological objectives into the forest planning process.

Another theme in the responses is the need to maintain a competitive forest sector by measures such as lowering the costs of regulation by moving away from prescriptive regulation to performance-based management.

4.8.6 Barriers to a solution

Respondents rate current efforts to manage forest issues as low. The principal barrier cited by respondents is the emphasis on shorter run economic objectives instead of longer run objectives of conservation. This is in part due to the sometimes difficult trade-off between the two objectives of maintaining industry competitiveness versus achieving conservation objectives which increase short

run costs and reduce harvest levels. The significant role that the forest industry plays in British Columbia's resource communities makes this a challenging trade-off to manage.

4.8.7 Knowledge gaps and research priorities

Principal knowledge gaps identified by respondents include understanding impacts of alternative harvesting approaches such as variable retention and other partial cutting techniques on forest regeneration, yields and ecological health. Other gaps are how to better integrate conservation objectives into the land-use planning process, how to determine a sustainable AAC that reflects all relevant values, and how to improve the overall competitiveness of the forest industry while achieving environmental objectives.

Recommended research priorities are research on the impacts of alternative harvesting methods on ecosystems, research on how to achieve better integration of conservation objectives into the planning process, and research on how to achieve higher productivity and more value added in the forest industry. Examination of alternative policy approaches such as tenure reform and new legislative and regulatory approaches is viewed as a key part of this research agenda.

4.9 Toxics

4.9.1 Overview

Toxic contaminants are substances that can negatively impact living organisms by disrupting their biochemical or physiological processes or functions. These negative effects can be realized either as a result of immediate, short-term exposure (acute toxicity) or more continual, long-term exposure (chronic toxicity). Some toxic substances, such as heavy metals, actually occur naturally in the environment. Usually it is only at unnaturally high concentrations that these substances have a toxic effect. Other toxic substances, such as PCBs, are exclusively man-made (Government of Canada 1996).

Toxic effects can vary widely. Human exposure to heavy metals may result in cancer, genetic mutations, birth defects, or damage to various tissues and organs, including the brain, kidney, skin and digestive, skeleto-muscular and nervous systems. Heavy metals also have the capacity to affect entire ecosystems at all levels, from the microbial processes in the soil, to the vegetation growing in that soil, to the entire food chain of organisms that feed on that vegetation. Chronic exposure to another group of toxics, the persistent organic pollutants (POPs), may result in reproductive (including intergenerational effects), metabolic, neurological, or behavioural abnormalities. Suppression of the immune system may also occur, possibly leading to increased incidence of cancer. Many of the toxic effects of POPs are thought to result from their ability to effectively mimic or perturb the actions of hormones in living organisms (Government of Canada 1996). Such POPs are often referred to as endocrine disruptors.

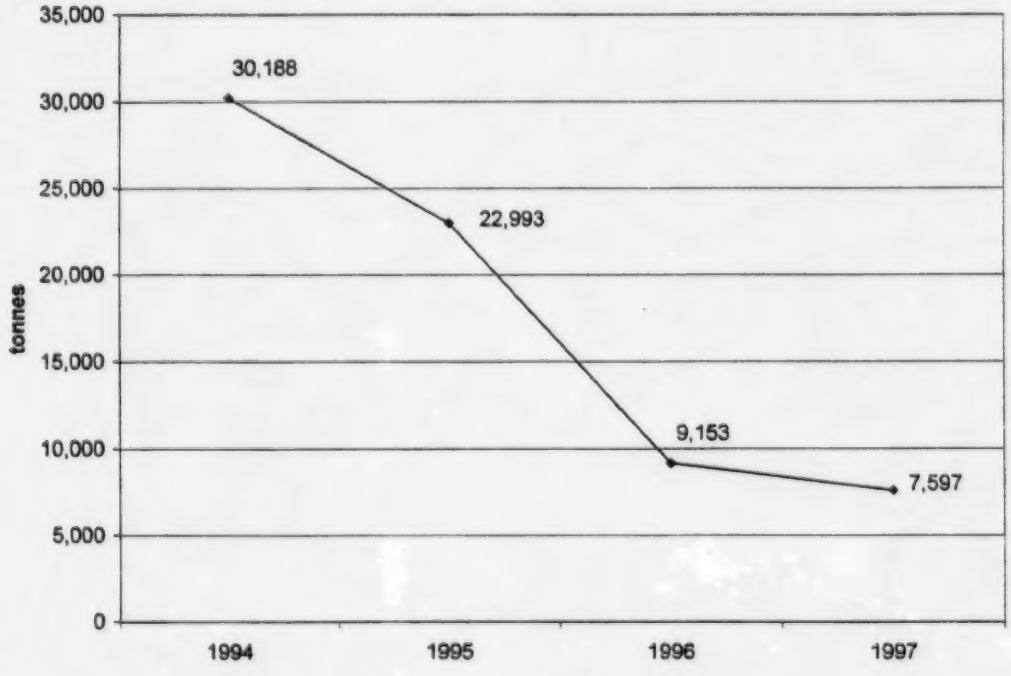
Long-term exposure to toxic substances which can resist metabolic degradation and excretion can result in an accumulation of these toxins within a living organism, effectively increasing the body burden of the organism. This effect is known as "bioaccumulation." Within a given food chain, a series of predators may consume such contaminated organisms. As the body burden increases with

each step up the food chain, the top predators become progressively more contaminated with the toxic substances. This effect is known as "biomagnification."

Toxics are a difficult issue to study and manage for several reasons. First, many are highly persistent -- they do not readily degrade into less toxic forms. As a result, the potential duration of exposure for living organisms once the toxic has been introduced into the environment is increased. Secondly, these substances may produce negative effects on living organisms, even at very low concentrations, as a result of long-term exposure. Furthermore, the effects of these chemicals can be very subtle, making it difficult to clearly establish a definitive cause and effect relationship. For example, some toxic substances only slightly impair mental function and memory, effects that are difficult to measure or quantify. Finally, there are so many toxic substances, so widely used, in so many applications, with new, potentially toxic chemicals being developed every day, that it is very difficult to comprehensively monitor and manage the issue (Government of Canada 1996).

In British Columbia, toxic pollutants are released into the environment every day. According to the National Pollutant Release Inventory, 77% of these releases are to air, 18% are to water, 5% are to land, and less than 1% is discharged underground (Ministry of Environment, Lands and Parks 1998). Figure 32 illustrates the discharge of toxics to the environment in BC in recent years, according to the National Pollutant Release Inventory (Environment Canada 1998).

Figure 32 Total tonnes of on-site toxic substances releases in BC 1994-1997

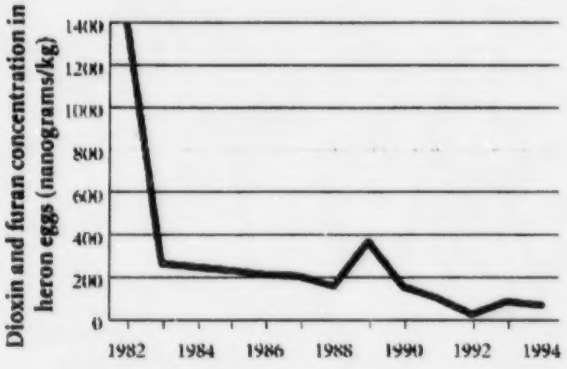


(Environment Canada 1998)

Based on monitoring data collected in the late 1980s, most coastal areas of BC are relatively uncontaminated with heavy metals except in some localized areas around some municipal outfalls, harbours, pulp mills and coastal mining sites (Ministry of Environment, Lands and Parks 1993).

Indicators also suggest that PCB levels are declining in the environment. The concentration of PCBs in the eggs of great blue herons has decreased by between 43 and 90% since 1977. Similarly, the concentration of dioxins and furans in this indicator species decreased by over 90% between 1982 and 1994, as illustrated in Figure 33 (Ministry of Environment, Lands and Parks 1998).

Figure 33 Dioxin and furan concentration in heron eggs



(Ministry of Environment, Lands and Parks 1998)

The manufacture of PCBs was banned in Canada in 1977. However, PCB can still be released to the environment if it spills from old equipment. This compound was extensively used in the past, such as in the dielectric fluid in electrical transformers. Many of these transformers are still in service throughout BC; those that have been removed from service are in storage because the PCBs they contain are extremely difficult to destroy.

Some government initiatives addressing this issue are listed in Appendix 4.

4.9.2 Impacts

Impacts of toxics identified by respondents include effects on human health and the ecosystem. Toxics accumulate in the ecosystem and move up through the food chain ultimately to humans, causing health problems intensified by biomagnification and intergenerational accumulation of toxics.

Although the general impacts are understood, respondents rate the overall understanding of toxic impacts a relatively low 4.59 on the 1 to 10 scale. The reason for this is that there are a large number of toxic contaminants that are hard to trace as they move through the ecosystem. It is also difficult to identify cause/effect relationships because of the high number of other contributing factors.

4.9.3 Monitoring

Respondents rate the adequacy of monitoring of toxics as poor. Although monitoring of point sources of toxics such as industrial sites is good, the monitoring of non-point sources is inadequate. According to some respondents, there is insufficient monitoring, poor data integration and management, and poor monitoring of toxics as they move through the ecosystem. Monitoring of impacts is also poor.

4.9.4 Causes

Respondents rate understanding of causes of toxic problems as a moderate 5.59 on the 1 to 10 scale. Although point sources of toxics contaminants are well understood, identification of the role of non-point sources is still deficient. The understanding of the impacts of many toxics and how they move through the ecosystem is also deficient.

4.9.5 Solutions

Understanding of solutions is rated by respondents as a moderate 5.45 on the 1 to 10 scale. Recommendations include stronger regulations based on industrial cradle-to-grave stewardship programs, incentives to develop safe alternatives, increased research on toxic impacts, and increased monitoring. Respondents also identify the need for increased cooperation between governments through mechanisms such as international and federal/provincial agreements to regulate the use and disposal of toxics.

4.9.6 Barriers to a solution

Respondents rate current efforts to manage toxics at 4.32 on the 1 to 10 scale. Although this is higher for toxics than most of the other nine environmental issues, it is still poor.

Key barriers to effective management identified by respondents are the large number of toxics in use, the economic costs of disposing and replacing them, scientific uncertainty regarding impacts of toxics, and overall lack of public pressure and will to improve the regulatory regime.

4.9.7 Knowledge gaps and research priorities

The key knowledge gap identified by respondents is understanding of impacts and tolerance levels for the large number of toxic substances in use.

Research priorities recommended by respondents are study of health impacts, safe alternatives to toxics, risk assessment to set priorities for toxic research, and management and design of effective monitoring systems.

4.10 Soils

4.10.1 Overview

Soil is a fundamentally important resource to British Columbia, giving rise to a number of valuable natural products such as timber and agricultural crops. As these products are repeatedly harvested, soil is expected to continue providing a stable, rich medium to support this growth. Furthermore, soils play an important role in providing grasslands essential for cattle grazing, as well as the basis for many large urban gardens and parks.

Effective soil management is important not only for maintaining soil productivity; soil also plays a number of important roles. For example, in the hydrologic cycle, soil absorbs and retains rain water, making it available for plant uptake. Some of the water not absorbed by plants is gradually released to nearby streams and river, avoiding floods following heavy rain events. Other rain water travels through soils to groundwater aquifers, recharging these aquifers with fresh water. Soil plays an important role in supporting dense populations of microbes and invertebrates that decompose dead organic matter, making nutrients available for living plants. Carbon is fixed from the atmosphere by soil into vegetative matter.

In the harvesting, replanting, and tending of vegetation supported by soils, these important soil characteristics can be compromised. One such concern is the compaction of soils. Soil compaction is effected by factors such as the weight of equipment passing over the soil surface, the moisture content of the soil, and the soil depth (Ministry of Forests 1999). Compacted soils have a diminished capacity to absorb and contain water, to support existing animal and plant life with adequate pore spaces, and to successfully give rise to a new generation of vegetation.

A second concern with soil management is erosion. Erosion is "the wearing away of the earth's surface by water and wind" (Ministry of Forests 1999). Erosion occurs naturally, but can be dramatically accelerated by human interaction with soils. Soil erosion is caused by exposure of the soil to water and wind without a vegetative cover and supporting root network to hold the soil in place. Soil compaction can exacerbate and contribute to soil erosion. In the agricultural lands of South Coastal BC, it is estimated that water erosion costs between $7 and $12 million annually. In the Southern Interior of BC, $1.2 to $1.8 million are lost annually because of erosion (Fraser Basin Management Program 1997). Soil erosion can also result in significant off-site pollution. Soil erosion into rivers may silt-up fish spawning areas, making them less productive. This silt can also make the water uninhabitable for fish and unsuitable for use as drinking water. Soil erosion can also contribute to air quality, as fine particulates are blown off-site.

Soils can be protected in forests by using cable or helicopter logging, minimizing road systems, and implementing drainage and erosion control measures (Ministry of Forests 1999). On agricultural lands, effective soil management includes reducing tillage practices, rotating crops, sowing crops across slopes along contours, grassing waterways, not working the land when it is saturated, and using winter cover crops (Fraser Basin Management Program 1997).

Some government initiatives addressing this issue are listed in Appendix 4.

4.10.2 Impacts

Respondents rate understanding of impacts of soil problems as a moderate 5.57 on the scale. Impacts cited include reduced fertility of soils, which results in lower productivity in resource-based industries such as forestry and agriculture; increased flooding caused by poor water retention in depleted soils; and reduced water quality caused by erosion.

4.10.3 Monitoring

Respondents rate monitoring of soils issues as only 3.07. This is the lowest rating for the nine environmental issues. Deficiencies include inadequate monitoring and poor integration of data. Long term trend monitoring is non-existent and extensive monitoring is only done when serious problems are observed.

4.10.4 Causes

Respondents rate understanding of causes as high, at 6.50 on the scale. Causes cited include agricultural and forestry practices that are too intensive, as well as inadequate monitoring and management efforts.

4.10.5 Solutions

Respondents rate understanding of solutions to soil problems as high, 6.5. Respondents identified three areas where soil management practices need to be addressed – forestry, urban land-use planning, and agriculture. A combination of regulation, education, and incentive approaches were suggested.

4.10.6 Barriers to a solution

Respondents rate current efforts to manage soil problems as a low 3.50; one of the very lowest of the nine environmental issues. The key barriers to effective management are lack of political will and public interest, the perceived economic costs of better conservation, and the large number of stakeholders involved.

4.10.7 Knowledge gaps and research priorities

Key knowledge gaps identified by respondents are assessing the extent of soil problems in British Columbia, assessing the impacts of present practices on soil productivity, fully understanding the relationship between nutrients (especially nitrogen) and fertility, and understanding the effectiveness of soil rehabilitation techniques. Respondents also identified the lack of soil experts in British Columbia.

Research priorities identified include better monitoring and inventory of soil conditions, understanding of impacts of alternative logging and farming techniques, and research on nutrient requirements for crops.

Chapter 5 Communication

5.1 Introduction

Cooperation among researchers and communication of research results are essential for improving knowledge necessary for sound environmental management. Part II of the questionnaire asked respondents to assess adequacy of communication among experts and the public, identify barriers to effective communication, and recommend ways to improve communication and synergies in the research community. The questions were open-ended and allowed for multiple responses.

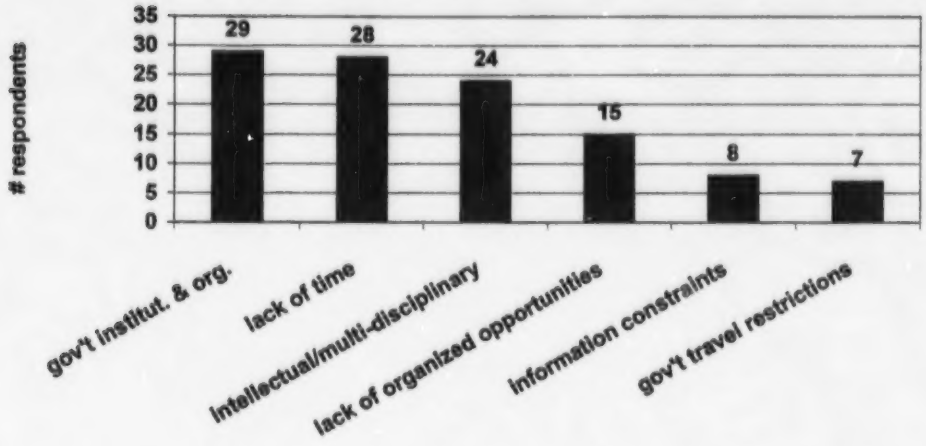
5.2 Communication Barriers

Respondents were asked to rate the opportunities for interchange among environmental experts on a scale from 1 to 10, with 1 being not at all adequate and 10 being very adequate. The average rating of 4.8 suggests that experts view the opportunities as moderately adequate. Academics tended to give higher ratings than provincial government employees. Respondents were also asked to rate how adequately environmental information is made available to the public. The average rating of 4.0 suggests that there are opportunities for improvement. Respondents in the non-government organization category gave significantly lower ratings.

The key barriers to communication among experts cited by the respondents are summarized in Figure 34. The most commonly cited impediment is government institutional and organizational barriers. Such barriers include the lack of a process to turn knowledge into policy, the lack of a coordinating body, the declining scientific capacity of government to provide comprehensive objective information, and inadequate encouragement of communication and professional development.

The second most commonly cited barrier was lack of time for interaction. This is cited most commonly by provincial government respondents. The third category of intellectual and multi-disciplinary barriers involves the propensity of individual disciplines to have their own separate meetings, research approaches, and language. This impedes the interdisciplinary interchange necessary for a sound understanding of environmental issues. Lack of forums and conferences on British Columbia environmental issues, restrictions on the distribution of information, and government travel restrictions are also cited as important constraints.

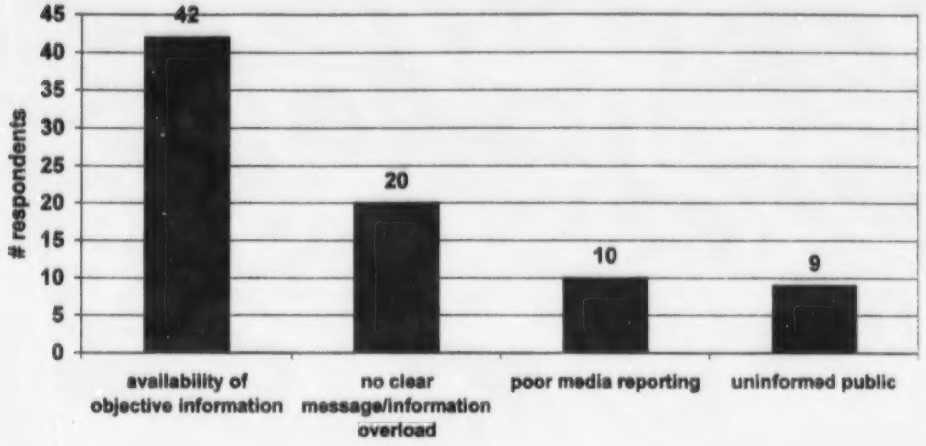
Figure 34 Part II – Barriers to expert communication
Part II, Question 2
What are the key barriers to communication
between environmental experts in British Columbia?



The key barriers to making environmental information available to the public are summarized in Figure 35. The top two barriers deal with the quality of information. The first barrier is the lack of available objective information which is viewed as credible and reliable. Many respondents cite perceived bias on the part of all parties providing environmental information. Furthermore, concerns about government's ability to make information available and communicate it effectively are raised. Respondents also conclude that there is too much information and that it is poorly organized; it does not provide a clear message to the public. This results in information overload for the public.

Two other barriers to effective dissemination of environmental information to the public are identified by respondents. One is that the media with its propensity to sensationalize issues does not report environmental issues very well. One expert cited the example of the media preparing a show on global warming and then canceling it when they could not find a scientist who was willing to argue that global warming was not occurring. Without a debate or conflict there was no interest in presenting important information on a key environmental issue. The second barrier was that the public does not have sufficient understanding or interest in environmental issues to appreciate the information being made available.

Figure 35 Part II – Barriers to communicating environmental information to the public
Part II, Question 5
What are the key barriers to adequately circulating
or making environmental information available to the public?



5.3 Improving Communication

After identifying barriers to communication, respondents were asked to propose ways of improving communication. The results are summarized in Figures 36 and 37.

The most common suggestion for improving communication among experts is to hold more and better forums and conferences focused on environmental issues in British Columbia. Some respondents suggested that an annual environmental conference should be held by an independent body such as a reconstituted Roundtable on the Environment and Economy to review major research findings relevant to British Columbia. The second most common suggestion was to improve government institutional culture by investing in good data management and supporting professional training and participation in professional activities by increasing funding for travel, professional conferences, and courses. A further suggestion was to require interdisciplinary research as a condition for research funding approval.

Suggestions for improving communication of environmental information to the public include better public reporting of information which is user friendly, widely disseminated, focused on key environmental indicators, and provided by an independent agency which has the confidence of information users. More forums and conferences are cited as a means for improving communication with the public. Improving environmental education in the schools is also referenced. An independent reporting authority could be effective in building public confidence in reported information.

Figure 36 Part II – Expert communication suggestions
Part II, Question 3
How could the communication between experts be improved in British Columbia?

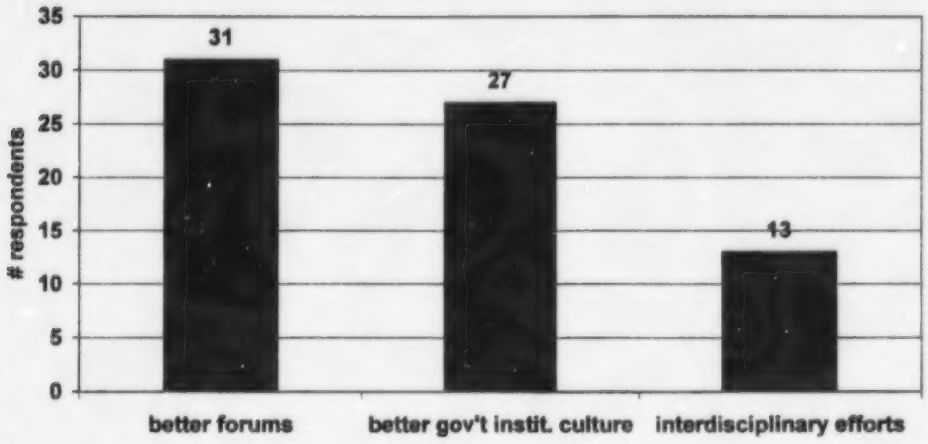
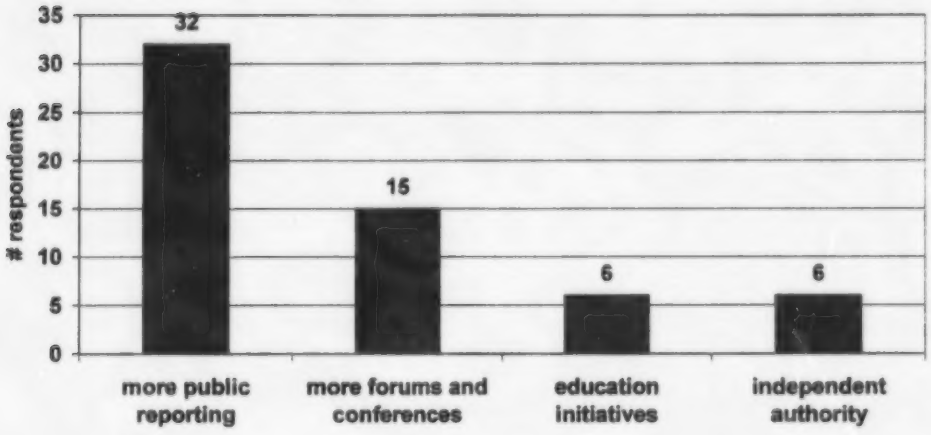


Figure 37 Part II – Public communication suggestions
Part II, Question 6
How could this communication between experts
and the public be improved in British Columbia?



Chapter 6 Conclusions

1) Respondents were asked to rank the severity of environmental issues in British Columbia in three different ways: unprompted open-ended questions, prompted numerical ratings of current severity, and a prompted numerical rating of future severity in the next 10 to 15 years. The prompted numerical ratings were based on the nine predefined environmental issues listed below. Although all nine issues are serious and require assiduous attention, it is possible to rank them into the following three categories based on the questionnaire results. Within each category of seriousness, there is no differentiation made between the issues listed.

Table 2 Seriousness of environmental issues considered

Very serious	Serious	Less serious
• Climate change/ Global warming • Fish resource management • Biodiversity • Water resource management	• Air quality • Forest resource management	• Stratospheric ozone layer depletion • Soil management • Toxics

2) The major causes of environmental problems identified by respondents are underlying values such as materialism or lack of appreciation for the significance of ecological values, overconsumption of resources, population growth, and inadequate policies and planning.

3) The key solutions to environmental problems identified by respondents are increased incentives to reward good environmental practices such as tax shifting, public environmental education, stronger implementation of environmental plans, and enforcement of regulations, better monitoring of outcomes, stronger integration of environmental objectives into decision-making, and increased scientific research in key areas summarized below.

4) The majority of respondents (78 %) expect British Columbia's environment to deteriorate over the next 10 to 15 years. Respondents also on average expect each of the nine environmental issues to become more serious over the next 10 to 15 years. The principal explanation for this trend cited by respondents is that the impacts of continued strong population and economic growth will outweigh improvements in environmental policy.

5) Knowledge of causes and solutions to environmental problems is generally ranked as moderate to high by respondents. Action to solve these problems is ranked relatively low for all problems except ozone. This suggests there is an "action gap" between what is possible to do to solve environmental problems and what is currently being done to solve environmental problems. The emphasis in environmental research should therefore be on how to achieve more effective policy implementation.

6) Respondents rate research communication within the environmental research community and communication between this community and the public as moderately adequate. Major constraints impeding communication and dissemination of research results are lack of time for interaction, institutional barriers impeding interchange between different agencies, intellectual

barriers impeding interaction between different disciplines, lack of organized forums for communication, and lack of objective information sources. Respondents' suggestions for improving communications and improving synergies in the research community include increasing support for research activities and professional development within government, increasing the number of conferences and forums for the interchange of research findings, and improving public reporting of environmental research.

7) In response to an open-ended question on research priorities, respondents identified several priority areas. The top three are generic areas of research relevant to all environmental areas. They include design and operation of a comprehensive state of environment monitoring system, policy research on how to integrate better environmental objectives into the decision-making process, and policy research on how to better implement environmental policies. Other research priorities identified by respondents include impacts of climate change, threats to fisheries, and research on how to protect biodiversity. Research on forestry, water, air and ecosystem issues were also mentioned.

8) Respondents were also asked to identify research priorities for each of the nine environmental problems. The results are summarized below.

Table 3 Research priorities for environmental issues

Environmental Category	Research Priorities
Climate Change/Global Warming	• policy design and implementation • impacts on regional ecosystems • alternative energy sources • adaptive strategies
Stratospheric Ozone	• compliance monitoring • impacts on flora and fauna • ozone layer dynamics
Air	• human health impacts • policy design and implementation
Water	• human health impacts of contaminants • policy implementation • monitoring water quality • watershed restoration
Biodiversity	• inventory and monitoring • habitat requirements of key species • impact of alternative resource harvesting
Forests	• impact of alternative harvesting methods • integrating environmental objectives into forest planning • relation between competitiveness and conservation
Fish	• impact of threats • inventory and stock assessment • alternate management regimes
Toxics	• impacts on human health and ecosystems • development of safe alternatives
Soils	• monitoring and inventory of soils • impact of alternative forest harvesting and agriculture methods

9) One of the initiatives recommended by respondents is the need for developing and implementing a comprehensive state of environment monitoring system which is based on sustainability indicators, provides an early warning system, gives a comprehensive assessment of environmental trends, is user friendly and independent of special interests. Some respondents recommended the need for having monitoring done by an independent agency structured under a separate statute specifying annual reporting requirements.

10) Another initiative recommended by respondents to increase synergies in environmental research is a regular environmental conference (organized by an independent entity such as a university) focusing on British Columbia environmental issues bringing together relevant stakeholders to discuss research findings.

11) A third initiative recommended by respondents is the need for increasing research efforts to fill the key knowledge gaps identified above. Respondents emphasize that research needs to be interdisciplinary and supported by stable funding. The Centres for Excellence approach in which

top researchers are integrated into a coordinated research effort appears to be the model that best meets this objective. Research institutes could be set up at British Columbia universities to manage and help coordinate research efforts such as high priority areas identified by respondents: environmental policy, climate change, fish, and biodiversity. Policy research could include research on environmental monitoring systems, implementation strategies such as tax shifting, and methods for integration of environmental objectives into decision-making.

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[1] Data prior to 1995 – (Levelton 1998)
Data from 1995 onward – (Alchemy Consulting Inc. and Levelton Engineering 2000) - scenario B
[2] Data prior to 1995 – (Levelton 1998)
Data from 1995 onward – (Alchemy Consulting Inc. and Levelton Engineering 2000) - scenario B

[3] In this citation, old growth is used to refer to lodgepole pine and deciduous species 121+ years old, coastal BC trees 250+, and 141+ for the rest of the province.
[4] Mature forests are defined as: stands with lodgepole pine, whitebark pine or deciduous species as leading species, of stand age greater than 80 years ; stands with conifers other than lodgepole or whitebark pine as leading species, of stand age greater than 120 years.
Immature forests are defined as: stands with lodgepole pine, whitebark pine or deciduous species as leading species, of stand age 80 years or less ; stands with conifers other than lodgepole or whitebark pine as leading species, of stand age 120 years or less.

Appendix One

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   Director, Research Branch, BC Ministry of Forests

7. **Mr. Scott Benton** – comprehensive expert
   Regional Director, Kootenay Region, BC Ministry of Environment, Lands and Parks

8. **Mr. Ron Bertrand** – specialist expert (soils)
   Director, Resource Management Branch, BC Ministry of Agriculture, Food and Fisheries

9. **Dr. Wolfgang Binder** – specialist expert (ozone)
   Research Scientist, Research Branch, BC Ministry of Forests

10. **Dr. Art Bomke** – specialist expert (soils)
    Associate Professor, Faculty of Agricultural Sciences, University of British Columbia

11. **Dr. Max Bothwell** – specialist expert (ozone)
    Research Scientist, National Water Research Institute, Environment Canada
    Adjunct Professor, Department of Biology, University of Victoria
    Adjunct Professor, Department of Biological Sciences, University of Alberta

12. **Mr. David Boyd** – comprehensive expert
    Senior Associate, Eco-Research Chair in Environmental Law and Policy, University of Victoria

13. **Mr. David Cadman** – comprehensive expert
    President, Society for Promoting Environmental Conservation
    Chair, BC Environmental Network

14. **Mr. Steve Chatwin** – specialist expert (water)
    Manager, Fish-Forestry and Watershed Research, BC Ministry of Forests

15. **Dr. Parzival Copes** – specialist expert (fish)
Emeritus Professor of Economics, Simon Fraser University
Institute of Fisheries Analysis

16. **Dr. Ray Copes** – specialist expert (air, water, toxics)
Medical Specialist, Risk Assessment & Toxicology, BC Ministry of Health
Clinical Assistant Professor, Department of Health Care & Epidemiology and School of Occupational & Environmental Hygiene, University of British Columbia

17. **Mr. Peter Davidson** – comprehensive expert
Forest Ecosystem Specialist, BC Ministry of Environment, Lands and Parks

18. **Dr. Chad Day** – comprehensive expert
Professor, School of Resource and Environmental Management, Simon Fraser University

19. **Mr. Ronald Driedger** – comprehensive expert
Director, Pollution Prevention & Remediation Branch, BC Ministry of Environment, Lands and Parks

20. **Mr. Wally Eamer** – comprehensive expert
Regional Director, Omineca Peace Region, BC Ministry of Environment, Lands and Parks

21. **Mr. Don Fast** – comprehensive expert
Assistant Deputy Minister, Environment and Lands Headquarters Division, BC Ministry of Environment, Lands and Parks

22. **Mr. Jock Finlayson** – comprehensive expert
Vice President and Chief Economist, Business Council of British Columbia

23. **Mr. Glyn Fox** – specialist expert (toxics)
Senior Risk Assessment Officer, Contaminated Sites Remediation Unit, Pollution Prevention and Remediation Branch, BC Ministry of Environment, Lands and Parks

24. **Mr. Jim Fulton** – comprehensive expert
Executive Director, David Suzuki Foundation

25. **Mr. Terry Glavin** – specialist expert (fish)
Member, Pacific Fisheries Resource Conservation Council

26. **Mr. Bud Graham** – specialist expert (fish)
Assistant Deputy Minister, BC Fisheries

27. **Dr. Stephen Grundy** – specialist expert (toxics)
Director, Science, Technology and Environment Division, Royal Roads University

28. **Dr. Ken Hall** – specialist expert (water, toxics)
Professor, Institute for Resources and Environment, University of British Columbia

29. **Ms. Linda Hannah** – comprehensive expert
Assistant Deputy Minister, Policy, Planning and Liaison, BC Fisheries

30. **Mr. Michael Harcourt** – comprehensive expert
Senior Associate, Sustainable Development Research Institute, University of British Columbia
Chair, Sustainable Cities Initiative, National Roundtable on the Environment and Economy

31. **Mr. Ron Heppner** – specialist expert (forests, biodiversity)
Forest Entomologist/Biodiversity Forester, BC Ministry of Forests

32. **Ms. Ann Hillyer** – comprehensive expert
Hillyer Atkins, Barristers & Solicitors
Board Member, West Coast Environmental Law Association and Research Foundation
Associate Faculty, Royal Roads University, Masters Program in Environment and Management
Academic Director and Visiting Professor, Environmental Law Summer 2000 Term Program, Faculty of Law, University of Victoria

33. **Dr. Anthony Hodge** – comprehensive expert
President, Anthony Hodge Consultants Inc.
Associate, International Institute for Sustainable Development
Adjunct, Graduate Program, Environment and Management, Royal Roads University
Adjunct, School of Public Administration, University of Victoria

34. **Ms. Vicky Husband** – specialist expert (forests, biodiversity)
Conservation Chair, Sierra Club of BC

35. **Dr. Mark Jaccard** – specialist expert (climate change)
Professor, School of Resource and Environmental Management, Simon Fraser University

36. **Ms. Laura Jones** – comprehensive expert
Director, Environment and Regulatory Studies, the Fraser Institute

37. **Dr. Perry Kendall** – comprehensive expert
Provincial Health Officer, BC Ministry of Health

38. **Mr. Pradeep Khare** – specialist expert (water)
Deputy commissioner, BC Oil and Gas Commission

39. **Dr. James Peter (Hamish) Kimmins** – comprehensive expert
Professor of Forest Ecology, Faculty of Forestry, University of British Columbia

40. **Dr. Leslie King** – comprehensive expert
Chair, NW Region, and Professor, Environmental Studies, University of Northern British Columbia

41. **Dr. Grant Kowalenko** – specialist expert (soils)
Head, Soil and Environmental Protection Section, Pacific Agri-Food Research Centre, Agriculture Canada

42. **Mr. Herbert Langin** – comprehensive expert
Regional Director, Cariboo Region, BC Ministry of Environment, Lands and Parks

43. **Dr. L. M. (Les) Lavkulich** – comprehensive expert
Director, Institute for Resources and Environment, University of British Columbia

44. **Dr. Terence Lewis** – specialist expert (soils)
Consultant in soils and land-use
Chairman, Joint Practices Board of the Association of BC Registered Professional Foresters and the Association of Professional Engineers and Geoscientists of BC

45. **Dr. Sylvia L'Hirondelle** – specialist expert (ozone)
Research scientist, Research Branch, BC Ministry of Forests

46. **Mr. David Marshall** – specialist expert (water)
Executive Director, Fraser Basin Council

47. **Dr. Arthur Martell** – comprehensive expert
Regional Director General, Pacific & Yukon Region, Environment Canada

48. **Mr. Robert Maxwell** – specialist expert (soils)
Soils Specialist, Wildlife Inventory Section, Resources Inventory Branch, BC Ministry of Environment, Lands and Parks

49. **Mr. Jim McCracken** – comprehensive expert
Regional Director, Lower Mainland Region, BC Ministry of Environment, Lands and Parks

50. **Dr. Tim McDaniels** – comprehensive expert
Associate Professor, Institute for Resources and Environment, University of British Columbia

51. **Dr. J. D. McTaggart-Cowan** – specialist expert (climate change, ozone, air quality)
Professor, Environmental Sciences, Royal Roads University

52. **Mr. Morris Mennell** – specialist expert (air quality)
Administrator, Air Quality Management Division, Greater Vancouver Regional District

53. **Dr. Jon O'Riordan** – comprehensive expert
Assistant Deputy Minister, Environment and Lands Regions Division, BC Ministry of Environment, Lands and Parks

54. **Mr. Chris Pharo** – specialist expert (water)
Manager, Pacific Environmental Science Centre, Environment Canada

55. **Dr. Jim Pojar** – specialist expert (forests, biodiversity)
Research Ecologist, BC Ministry of Forests

56. **Dr. John Pringle** – specialist expert (fish)
Head, Marine Environment & Habitat Sciences, Science Branch, Institute of Ocean Sciences, Fisheries and Oceans Canada

57. **Dr. William Rees** – comprehensive expert
Professor, immediate past-Director, School of Community and Regional Planning, University of British Columbia
Executive Member and immediate past-President, Canadian Society for Ecological Economics

58. **Dr. John Robinson** – comprehensive expert
Director, Sustainable Development Research Institute, University of British Columbia
Professor, Faculty of Geography, University of British Columbia

59. **Ms. Ann Rowan** – specialist expert (forestry, biodiversity, fish)
Project Director, Pacific Salmon Forests Project, David Suzuki Foundation

60. **Mr. Steve Samis** – specialist expert (fish)
Chief, Water Quality Unit, Habitat & Enhancement Branch, Fisheries & Oceans Canada

61. **Dr. Paul Sanborn** – specialist expert (soils)
Research Soil Scientist, BC Ministry of Forests
Adjunct Professor, Forestry Program, University of Northern British Columbia

62. **Dr. Hans Schreier** – specialist expert (water)
Professor, Institute for Resources and Environment, University of British Columbia

63. **Mr. Gerry Scott** – specialist expert (climate change, air quality)
Director, Climate Change Campaign, David Suzuki Foundation

64. **Dr. Risa Smith** – comprehensive expert
Coordinator, State of Environment Reporting, BC Ministry of Environment, Lands and Parks

65. **Mr. Cliff Stainsby** – comprehensive expert
Researcher, BC Government and Service Employees' Union

66. **Dr. Douw Steyn** – specialist expert (climate change, ozone, air quality)
Professor, Atmospheric Science, Department of Earth and Ocean Sciences, and Director of Science One Program, University of British Columbia

67. **Mr. Les Swain** – specialist expert (water)
Head, Water Management Branch, Standards and Protocols Unit, BC Ministry of Environment, Lands and Parks

68. **Mr. Bill Taylor** – specialist expert (ozone)
Climatologist, Environment Canada

69. **Mr. Eric Taylor** – specialist expert (climate change)
Regional Climatologist, Environment Canada

70. **Mr. John Thompson** – comprehensive expert
Regional Director, Southern Interior, BC Ministry of Environment, Lands and Parks
(with input from:
Bob Grace, Impact Assessment Biologist, Pollution Prevention Program
Laing Shimmin, Manager, Water Management Program
Ted Fuller, Geomorphologist, Water Management Program
Al Breitkreutz, Manager, Conservation Officer Program
Charles Porter, Manager, Fish-Wildlife-Habitat-Planning Program
Mike Watkins, Planning Officer, Fish-Wildlife-Habitat-Planning Program)

71. **Mr. Bruce Torrie** – specialist expert (ozone)
Executive Director, Skies Above Foundation

72. **Ms. Wendy Irish Turner** – specialist expert (water)
Director, Fraser Basin Council Board
Director, Fraser River Coalition

73. **Mr. Graham van Aggelen** – specialist expert (toxics)
Senior Scientist, Pacific Environmental Science Centre, Environment Canada

74. **Ms. Toby Vigod** – comprehensive expert
Chair, Environmental Appeal Board and Forest Appeals Commission

75. **Mr. Hu Wallis** – specialist expert (air quality)
Manager, Air Quality Assessment, Air Resources Branch, BC Ministry of Environment, Lands and Parks

76. **Dr. Gerald Walter** – comprehensive expert
Professor, Department of Economics, University of Victoria

77. **Mr. Earl Warnock** – comprehensive expert
Regional Director, Vancouver Island Region, BC Ministry of Environment, Lands and Parks

78. **Dr. Andrew Weaver** – specialist expert (climate change)
Professor, School of Earth and Ocean Sciences, University of Victoria

79. **Dr. Paul West** – comprehensive expert
Director, School of Environmental Studies, University of Victoria

80. **Ms. Nancy Wilkin** – specialist expert (forests, biodiversity)
Chief Negotiator, Ministry of Aboriginal Affairs

81. **Mr. Richard Williams** – specialist expert (climate change)
Manager, Environment, Health, Safety & Sustainable Development, Westcoast Energy Inc.

82. **Mr. Ed Wituschek** – specialist (air quality)
Acting Manager, Commercial Chemicals Division, Environment Canada

83. **Ms. Karen Wristen** – comprehensive expert
Executive Director, Sierra Legal Defence Fund

Appendix 2

Questionnaire - Assessment of Research Priorities for Environmental Management in British Columbia

BACKGROUND INFORMATION

Please describe the following aspects of your work. The information provided will be used to compile a summary description of the environmental experts interviewed in this study. This summary will be included in the final report.

Name:

Institutional affiliation(s) and position(s) currently held:

Brief description of current research interests and specialty areas:

Please list your advanced education degrees by discipline:

How would you define your current discipline? (please chose one)

Biologist
Ecologist
Economist
Engineer
Forester
Geographer
Lawyer
Medical doctor
Planner
Political Scientist
Other…

☑ Please ensure that your contact information (phone number, mailing address, etc.) are included with your return email.

PART I Overall Environmental Problems

The following questions are designed to be open-ended, allowing you maximum flexibility in your responses. The words "serious" and "environmental problem" are not explicitly defined, nor are criteria suggested with which to answer these questions. Instead, we rely on your overall knowledge and experience to answer these questions using definitions and criteria as you think most appropriate. Please answer these questions as an independent expert in the environmental field, not necessarily as a representative of your organization.

1. Considering both current and future implications, what are the most serious environmental problems in BC?

2. Why do you think these problems are so serious?

3. What would you identify as the most significant underlying causes of environmental problems in BC?

4. What are the most significant steps the BC government could take to address environmental problems?

5. What is the single most significant step the BC government could take to address environmental problems?

6. What should be the environmental research priorities in BC? (The word research includes the full range of research activities, from pure to applied research, in all topic areas, including law, policy, science, etc.)

7. What should be the top environmental research priority in BC?

8. On a scale of 1 to 10, how do you think BC's environmental quality is likely to change over the next 10 to 15 years?

   Where:
   1 significant deterioration
   5 no change
   10 significant improvement

   1 2 3 4 5 6 7 8 9 10

9. Please provide the rationale for your answer to question 8.

PART II Communication

1. On a scale from 1 to 10, how adequate are the current opportunities for environmental experts in British Columbia to exchange information with each other?

   Where:
   1 not at all adequate
   10 very adequate

   1 2 3 4 5 6 7 8 9 10

2. What are the key barriers to communication between environmental experts in British Columbia?

3. How could the communication between experts be improved in British Columbia?

4. On a scale from 1 to 10, how adequately is environment information circulated or made available to the public?

   Where:

   1 not at all adequate
   10 very adequate

   1 2 3 4 5 6 7 8 9 10

5. What are the key barriers to adequately circulating or making environmental information available to the public?

6. How could this communication between experts and the public be improved in British Columbia?

PART III Seriousness of Specific Environmental Problems

Based on your general knowledge and expertise of environmental problems, please answer the following questions:

1. On a scale from 1-10, how serious do you think each of these problems is for British Columbia currently? (answer in the table below)

2. On a scale from 1-10, how serious do you think each of these problems will be for British Columbia in 10 to 15 years? (answer in the table below)

   1 not at all serious
   10 extremely serious

The following problem descriptions are provided to give a general idea of the problem area being considered. They are not intended to be an all-inclusive, definitive description of the problem.

Environmental Problems in British Columbia	How serious currently? (1-10)	How serious in 10 to 15 years? (1-10)
1. Global warming and climate change Elevated levels of greenhouse gases causing changes to the earth's climate.		
2. Stratospheric ozone layer depletion Ozone-depleting substances thinning ozone layer in stratosphere.		
3. Air quality Concentrations of contaminants in the air throughout BC that result in poor air quality.		
4. Water resource management Concentrations of contaminants and altered physical characteristics of surface and groundwater that result in poor water quality, water exports, flooding, groundwater extraction, community water supply, watershed management.		

PART III continued...

Environmental Problems in British Columbia, cont.	How serious currently? (1-10)	How serious in 10 to 15 years? (1-10)
5. Biodiversity and endangered species Decreasing genetic diversity (variation among individuals of the same species), species diversity, and ecosystem diversity (habitat).		
6. Fish resource management Declining fish stocks, habitat loss, weakened supporting aquatic ecosystems, overfishing, etc.		
7. Forest resource management Rate and distribution of timber harvest, ,harvesting techniques, reforestation and silviculture systems, protected areas		
8. Concentration of toxic contaminants in environment Increasing metals, organochlorines, endocrine disruptors, etc.		
9. Soil management soil erosion, soil salinization, soil nutrient depletion, soil structure destruction		
If there is any additional problem that you think is serious and not already included in one of these ten groupings, please identify this problem here and grade the seriousness of the problem. **11. Other...**		

PART IV Individual Environmental Problems

The individual environmental problems identified in the previous table (Part III) are now considered separately. The same series of detailed questions (sections A through E) are used to further investigate each problem. These detailed questions are based on the following:

- Section A. What are the impacts of this problem?
- Section B. How adequate is our monitoring of the problem?
- Section C. What are the causes of the problem?
- Section D. What are solutions to the problem?
- Section E. What should the priorities be regarding this problem?

Comprehensive experts were asked:
Please answer these detailed questions for as many of the nine environmental problems identified in part III for which you feel you have appropriate expertise and knowledge. You are not expected to answer the following questions for all nine problems.

Specialist experts were asked:
Please answer these detailed questions for the environmental problems of ***(their area(s) of expertise was named here)*** specifically.

A. Impacts

A1. What are the key impacts of this problem, both current and future, in British Columbia?

A2. On a scale of 1 to 10, how well do we understand the impacts of this problem in British Columbia?

Where:
1 we have no understanding
10 we have a thorough understanding

1 2 3 4 5 6 7 8 9 10

B. Monitoring the problem

B1. On a scale of 1 to 10, how good is our basic monitoring data for this problem in British Columbia in terms of informing the management of the problem?

Where:
1 very poor quality and quantity monitoring data
10 excellent quality and quantity monitoring data

1 2 3 4 5 6 7 8 9 10

B2. What are the key gaps in our monitoring of this problem in British Columbia?

C. Causes of the problem

C1. What are the causes of the problem?

C2. In terms of being able to manage the problem, how well do we understand the causes of the problem on a scale from 1 to 10?

Where:
1 we have no understanding
10 we have a thorough understanding

1 2 3 4 5 6 7 8 9 10

D. Solutions

D1. How do you think we, in British Columbia, should solve the problem?

D2. On a scale from 1 to 10, how well do we understand how to solve the problem?

Where:
1 we have no understanding
10 we have a thorough understanding

1 2 3 4 5 6 7 8 9 10

D3. On a scale from 1 to 10, how adequately are we currently addressing the problem?

Where:
1 we are not addressing the problem adequately at all
10 we are addressing the problem very adequately

1 2 3 4 5 6 7 8 9 10

D4. What are the most prevalent barriers in British Columbia preventing us from solving the problem?

E. Prioritization:

E1. What do you think are the key knowledge gaps that must be addressed in order to manage this problem in British Columbia?

E2. What do you think should be the key research priorities for this problem in British Columbia? (The word research includes the full range of research activities, from pure to applied research, in all topic areas, including law, policy, science, etc.)

E3. Of the research priorities, which should be the highest priority?

E4. Is there any other aspect of this problem not yet mentioned which you would like to discuss? If so, please elaborate.

END OF QUESTIONNAIRE
THANK YOU FOR YOUR RESPONSES

Appendix 3

Statistical Summary and Responses

	Median	Average	Standard Deviation
PART ONE			
Question 8			
On a scale from 1-10, how do you think BC's environmental quality is likely to change over the next 10 to 15 years?	3	3.45	1.7
PART TWO			
Question 1			
On a scale from 1-10, how adequate are the current opportunities for experts in BC to exchange information with each other?	4	4.81	2.33
Question 4			
On a scale from 1-10, how adequately is environmental information circulated or made available to the public?	3	4.03	2.19
PART THREE	**Median**	**Average**	**Standard Deviation**
On a scale from 1-10, how serious do you think each of these problems is for BC -			
Question 1			
Currently?			
Climate change	5	5.28	2.85
Stratospheric Ozone Layer Depletion	4	4.66	2.45
Air quality	6	5.96	2.2
Water quality	6	6.03	2.15
Biodiversity	6	5.99	2.25
Fish resource management	7	7.3	1.77
Forest resource management	6	6.55	2.09
Toxics	6	5.45	2.21
Soil management	5	5.04	2.24
Question 2			
In 10 to 15 years?			
Climate change	8	7.49	2.38
Stratospheric Ozone Layer Depletion	5	5.28	2.63
Air quality	7	6.97	2.4
Water quality	8	7.4	2.16
Biodiversity	8	7.45	2.29
Fish resource management	8.5	8.09	1.94
Forest resource management	7	6.65	2.38
Toxics	7	6.21	2.38
Soil management	6	6.06	2.47

Percentage of respondents for whom the seriousness of individual issues changes between now and 10-15 years from now for the:

	worse	same*	better
Climate change	74%	24%	1%
Stratospheric Ozone Layer Depletion	42%	34%	24%
Air quality	64%	20%	16%
Water quality	72%	19%	9%
Biodiversity	78%	14%	9%
Fish resource management	62%	24%	14%
Forest resource management	42%	25%	34%
Toxics	55%	23%	22%
Soil management	64%	31%	4%

* some responses may be the same because they were already at the top of the scale (10 both currently and in the future).

PART FOUR*	Median	Average	Standard Deviation
Climate change			
A2 - Impacts	3	3.81	1.93
B1 - Monitoring	3	3.76	2
C2 - Causes	6.5	6.44	2.53
D2 - Solutions	4	5.19	2.5
D3 - Action	2	2.17	1.08
Stratospheric Ozone Layer Depletion			
A2 - Impacts	6.5	5.77	2.64
B1 - Monitoring	4.5	5.05	2.28
C2 - Causes	8	7.52	2.23
D2 - Solutions	8	7.17	2.55
D3 - Action	6	6.09	2.63
Air quality			
A2 - Impacts	7	6.69	1.77
B1 - Monitoring	5.5	5.64	1.66
C2 - Causes	8	7.21	1.26
D2 - Solutions	7	6.93	1.51
D3 - Action	5	4.75	1.86
Water Resource Management			
A2 - Impacts	6	5.9	1.92
B1 - Monitoring	3	3.67	1.63
C2 - Causes	7	6.67	1.71
D2 - Solutions	7	6.4	1.85
D3 - Action	3	3.63	1.9
Biodiversity			
A2 - Impacts	5	4.64	1.81
B1 - Monitoring	3	3.32	1.52
C2 - Causes	7	6.15	1.81
D2 - Solutions	6	5.7	2
D3 - Action	3	3.44	1.85

Fish Resource Management			
A2 - Impacts	6	5.6	1.66
B1 - Monitoring	4	4.41	1.71
C2 - Causes	5	5.42	1.77
D2 - Solutions	6	5.63	1.61
D3 - Action	3	3.54	1.53
Forest Resource Management			
A2 - Impacts	7	6.68	2.04
B1 - Monitoring	4	4.52	2.24
C2 - Causes	7	6.72	1.9
D2 - Solutions	6	6	2.04
D3 - Action	3	3.6	1.89
Toxics			
A2 - Impacts	4.5	4.59	2.63
B1 - Monitoring	4	3.76	1.97
C2 - Causes	6	5.59	2.28
D2 - Solutions	5.5	5.45	2.32
D3 - Action	4	4.32	2.06
Soil management			
A2 - Impacts	5.5	5.57	2.06
B1 - Monitoring	3	3.07	1.21
C2 - Causes	7	6.5	2.07
D2 - Solutions	7	6.5	1.65
D3 - Action	3	3.5	1.09

*** Part Four questions:**

A2. On a scale of 1 to 10, how well do we understand the impacts of this problem in British Columbia?
Where: 1 (we have no understanding), 10 (we have a thorough understanding)

B1. On a scale of 1 to 10, how good is our basic monitoring data for this problem in British Columbia in terms of informing the management of the problem?
Where 1 (very poor quality and quantity of monitoring data), 10 (excellent quality and quantity of monitoring data)

C2. In terms of being able to manage the problem, how well do we understand the causes of the problem on a scale from 1 to 10?
Where 1 (we have no understanding), 10 (we have a thorough understanding)

D2. On a scale from 1 to 10, how well do we understand how to solve the problem?
Where 1 (we have no understanding), 10 (we have a thorough understanding)

D3. On a scale from 1 to 10, how adequately are we currently addressing the problem?
Where 1 (we are not addressing the problem adequately at all), 10 (we are addressing the problem very adequately).

Appendix 4

GOVERNMENT INITIATIVES

The following is a list of government initiatives related to the environmental issues addressed in this report. This is by no means intended to be a comprehensive list of initiatives. Rather, it reflects some of the initiatives encountered while researching this report. Readers interested in knowing more about government initiatives should refer to the references cited at the end of the report.

The environmental experts interviewed in this study were not asked to comment on the following specific initiatives. As such, no evaluation of the effectiveness of these specific initiatives was done.

Climate change/Global warming

- **Kyoto Protocol** – In 1997, Canada participated in the development of the Kyoto Protocol, an international agreement to reduce global GHG emissions. If the agreement is ratified and comes into force, Canada will be required to reduce GHG emissions to 6% below 1990 levels by between 2008 and 2012.
- **National Climate Change Process** – initiated to develop a National Implementation Strategy. In this process, 450 experts from government, industry, academia and non-governmental organizations are working together to develop a national strategy to be presented at the next international meeting in November 2000.
- **Canadian Foundation for Climate and Atmospheric Sciences** – an independent body created by the federal government to fund science research in climate change, extreme weather, and air quality.
- **Sustainable Development Technology Fund** – a federal initiative to stimulate the development and demonstration of environmental technologies such as fuel cells and clean coal technologies.
- **Climate Change Action Fund** – a federal initiative to enable government to work on public outreach and education, demonstration and deployment of technology, and further our understanding of climate change and how to adapt to it.
- **Greenhouse Gas Emission Reduction Trading Pilot** – a national project testing the effectiveness of emissions trading in Canada.
- **BC Greenhouse Gas Forum** – established to advise the BC government on how to reduce GHG emissions.
- **BC Clean Vehicles and Fuels Program** – legislation setting more stringent standards for vehicle emissions and pollutants in fuels.
- **BC's Public Buildings Energy Retrofit Program** – a showcase for cleaner technologies.
- **BC Transportation Demand Management Plans**
- **BC's Green Economy initiative**
- **BC's Clean Energy initiative**

Stratospheric ozone layer depletion

- **Montreal Protocol on Substances that Deplete the Ozone Layer** (and subsequent amendments) -- an international plan to cut ODS use and production in developed countries by 97% compared to 1986 levels. Canada is a signatory to this protocol.
- **Ozone-Depleting Substances (ODS) Regulation** -- federal legislation
- **Ozone-Depleting Substances (ODS) Products Regulation** – federal legislation
- **BC's Ozone Depleting Substances (ODS) Regulation** – provincial legislation prohibiting the venting of ODSs and requiring the recovering and recycling of ODSs from air conditioners, foam materials, solvents, and sterilizing equipment.

Air quality

- **BC's Clean Vehicles and Fuels Program** – part of the provincial Waste Management Act, this program regulates fuel quality and vehicle emissions.
- **AirCare** -- used in the Lower Fraser Valley to reduce vehicle smog and pollution.
- **Air quality management plans** -- developed in a number of sensitive areas of BC.
- Further measures include provincial regulations to reduce the smoke from land-clearing, open burning and wood stoves, and to phase out beehive burners.

Water resource management

- **BC Non-point Source (NPS) Pollution Action Plan** – plan outlining six initiatives: education and training; prevention at the site; land-use planning, coordination and local action; assessment and reporting; economic incentives; and legislation and regulation.
- Provincial industrial pollution prevention projects, agricultural codes of practice, sewage treatment facility upgrades, community watershed inventory programs, and enhanced groundwater inventory activities also address water quality.
- **BC Fish Protection Act, Forest Practices Code, Watershed Restoration Program, Watershed Plans** – address water quality for fish.
- **BC Flood Protection Assistance Fund** – cost sharing assistance for local governments investing in flood protection planning and implementation.

Biodiversity

- **Committee on the Status of Endangered Wildlife in Canada (COSEWIC)** – national committee that monitors the possible extinction of known species, identifying threatened and endangered species.
- **Convention on Biological Diversity** – international convention for the conservation of biological diversity and the sustainable use of ecosystems, species and genetic resources. Signed by Canada and 167 other countries.
- **Canadian Biodiversity Strategy** – developed nationally by federal, provincial, territorial representatives, and nongovernmental groups with five strategic goals including the conservation of biodiversity, promotion of public understanding, and the maintenance or development of incentives and legislation to support the goals.
- **National Accord for Protection of Species at Risk** – agreement by all the provinces to protect species and their habitats and develop recovery plans for nationally designated threatened or endangered species.
- **BC's Protected Areas Strategy** – provincial initiative to protect 12% of BC's land base, designating areas without forest harvesting and mining as protected areas.
- **BC's Marine Protected Areas Strategy** -- a system of marine and coastal protected areas in BC to be established by 2010 following planning and public consultation.
- Conservation strategies have been developed for several species in BC, such as the grizzly bear and mountain caribou, for which the historical range has dramatically declined.
- **BC Fish Protection Act** – provincial legislation allowing for the designation of sensitive streams in southern BC, and for the priority of water flows for fish on those streams.
- **BC Forest Practices Code (FPC)** – The Identified Wildlife Management Strategy, part of the FPC, provides for the establishment of Wildlife Habitat Areas with prescribed practices for the protection of selected forest-dependent species. Additional key parts of the FPC intended to protect biodiversity, such as the Landscape Unit Planning and Winter Ungulate Ranges requirements, have yet to be fully implemented.

Fish resource management

- **Fisheries Act** – national legislation which, among other measures, prohibits the depositing of deleterious substances into water frequented by fish or the harmful alteration, disruption or destruction of fish habitat.
- **Habitat restoration and salmon enhancement program** – federal initiative
- **BC's Fish Protection Act** – provincial legislation focusing on four major objectives: ensuring sufficient water for fish; protecting and restoring fish habitat; improved riparian protection and enhancement; and stronger local government powers in environmental planning.
- **BC's Urban Salmon Habitat Program**
- **BC's Watershed Restoration Program**
- **Fisheries Renewal BC** -- supports fish and fish habitat restoration work throughout BC.
- **BC's Forest Practices Code** – provincial legislation requiring the maintenance of riparian reserves on larger streams where fish are present and recommending watershed assessments where logging practices may negatively impact fish.
- **BC Hydro's Water Use Planning process** – a mechanism to review BC Hydro's water licences and implement operational changes that will benefit fish.

Forest resource management

- **United Nations' Conference of Environment and Development – list of Forest Principles** - Canada is a signatory.
- **Canada Forest Accord** – Signed by government, industry and non-governmental organizations, this accord states that healthy forest ecosystems are essential to the health of all life on earth, and that a wide range of forest uses and interests should be incorporated in forest management.
- **The National Forest Strategy** – a federal initiative
- **Model Forests Program** – a federal initiative
- **BC's Forest Practices Code (FPC)** – promotes the management of forests for a full range of forest values in addition to timber values. These values include conservation of biodiversity, soil, water, fish and wildlife, as well as scenic, spiritual, and recreational values. Not all aspects of the FPC have been implemented.
- **BC's Land-Use Planning** initiative and **Protected Areas Strategy** plan the allocation of land for timber harvesting and the setting aside of land for protection and conservation.
- **Forest Renewal Plan** – to reinvest some of the wealth from the forests back into the forests and the communities supported by those forests.

Toxics

- **Canadian Environmental Protection Act**
- BC initiatives:
    - a program for the responsible management of household hazardous waste
    - new environmental quality standards and improvements to exiting regulations for the management of toxic wastes and contaminated sites
    - promoting Integrated Pest Management, intended to reduce the use of toxic contaminants in agriculture.
    - Pollution Prevention Planning programs for industry.

Soil management

- **Forest Practices Code** – components require forestry practices to consider soil degradation issues when working with soil.
- Provincially, the practices of farmers on the soils are monitored to estimate the extent of any soil management problems.
- Soil management issues in urban areas are typically controlled by local governments through their regulations regarding land development.